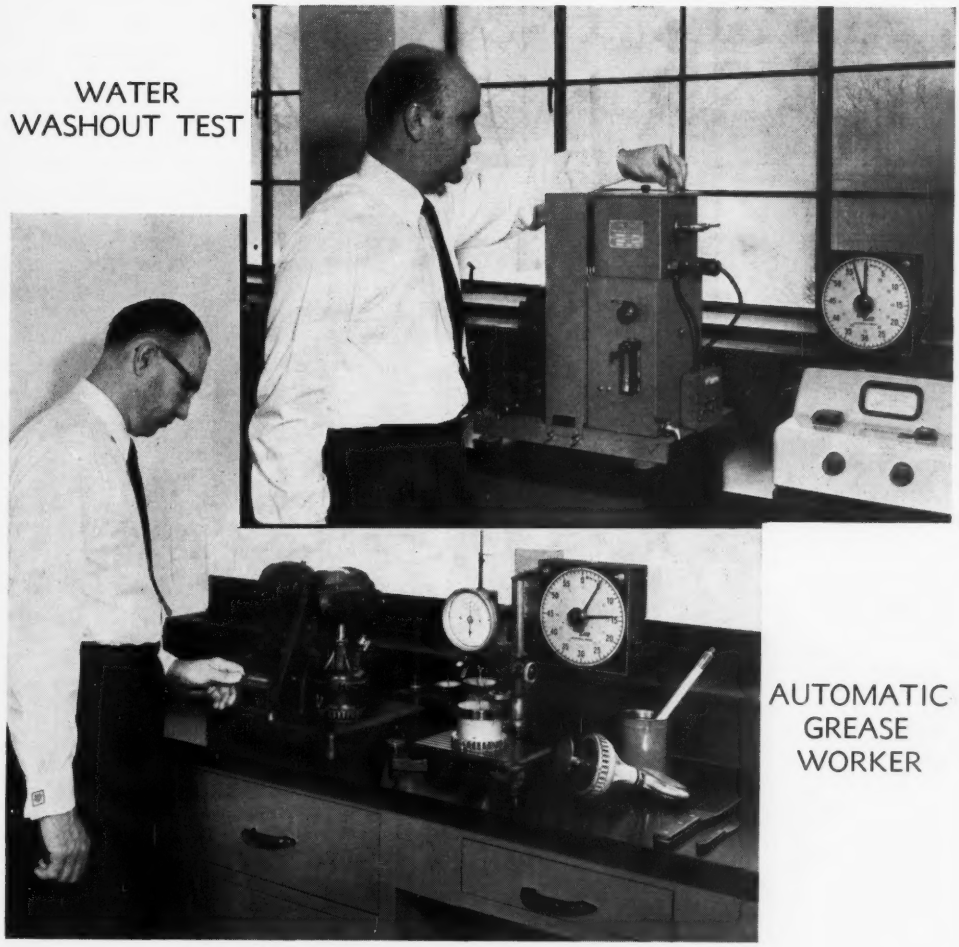
LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE



WATER WASHOUT TEST

AUTOMATIC GREASE WORKER

Modern Grease Testing **(See p. 198)**

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

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No. 218

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On this 1¼-inch Hill-Acme Upsetter, Farval's timing cycle can easily be changed to conform with the service of the machine. Amount of lubricant delivered to each bearing is also adjustable.

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When the going's rugged, with shock, vibration and wear trying to take their toll, Farval continuously guards 59 vital bearings . . . continuously delivers measured amounts of lubricant at regular intervals.

More and more, machine designers, engineers and production men are turning to Farval for the kind of lubrication that spells uninterrupted, maintenance-free production. Let us tell you more. Write for Bulletin 26-S. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

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LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 14, No. 5

May, 1958

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Second class mail privileges authorized at Chicago, Ill.

Personals

Government scientists Dr. H. Haller, U. S. Department of Agriculture, and Dr. William A. Zisman, chief of the surface chemistry branch of the Naval Research Laboratory, are heading divisions of the American Chemical Society. Dr. Haller is serving as the society's chairman of the division of agricultural and food chemistry while Dr. Zisman heads the ACS division of colloid chemistry.

Appointments of Thomas H. Pike, Jr. and John E. Chumbley as division vice presidents and F. E. MacDonald as controller were announced in Louisville, Ky. by Tube Turns, a division of National Cylinder Gas Co. of Chicago.

Ansul Chemical Co. of Marinette, Wisc. has appointed James B. Reed manager of Detroit operations (fire equipment sales).

Robert W. Ebey has been appointed manager of ball sales at the Hoover Ball and Bearing Co., Ann Arbor, Mich. Ebey joined the company in January 1957 as supervisor of inside sales. Prior to Ebey's appointment, the company's ball sales program was under the supervision of John B. Fyfe, assistant sales manager. Fyfe will retire on January 1, 1959 after more than 30 years' service with the company. Until then, he will serve in a staff capacity and continue to take an active part in the ball sales program. Also at Hoover, Marvin L. Walsh has been appointed assistant advertising manager with the responsibility for all of the company's collateral material.

Arthur D. Little, Inc., industrial research consulting company, has announced the election of Clarke Simonds and Joseph J. Snyder to its board of directors. Snyder is vice president and treasurer of the Massachusetts Institute of Technology and a partner in Colonial Management Associates of Boston, investment advisers. Simonds is managing partner of G. H. Walker & Co. of Providence, R. I.

James H. Carmine, former president of Philco Corp., has been appointed special consultant in sales, advertising, merchandising and marketing of Fram Corp., filter manufacturers of Providence, R. I.

Esso Standard Oil Company has announced formation of three sales service laboratories to be located at Baton Rouge, La., Bayonne, N. J., and Pittsburgh, Pa. Responsibility for the sales service activities of these laboratories has been assigned to Messrs. W. H. Brugmann, Jr. at Baton Rouge, G. W. Gleim at Bayonne and M. M. Gurgo at Pittsburgh.

Herbert S. Kindler of Mt. Lebanon, Pa. has assumed direction of educational services on the national headquarters staff of the Instrument Society of America where he has been director of technical programs. His new position, reflecting his additional educational activities, will be director, technical and educational services.

Baroid Division, National Lead Co., has announced the location of a New York office for Baroid Chemicals, Inc. at 111 Broadway in New York City. Edward Z. Walden, sales engineer for Baroid Chemicals will work in a dual capacity, serving also as export sales representative for Baroid Division at that address.

WATSON

GURGO

Promotion of Former Division Supervisor Carl E. Watson to technical assistant to the manager of the Petroleum Products Research Division at the Richmond laboratory of California Research Corp. has been announced.

Flexonics Opens West Coast Plant

Flexonics Corporation formally opened its new Santa Ana Division March 1, 1958 with a luncheon and plant tour for leaders of the California community. Serving as host was Kenneth G. Kampenga, factory manager of the Santa Ana Division. A reception was held later in the day for Flexonics' west coast customers and agents.

The Santa Ana Division, seventh facility to be opened by the Maywood, Illinois, firm since 1941, was started in October and finished in 54 working days. The plant was designed by Novikoff Engineering and built by Coordinated Construction Company, both of Los Angeles, California.

Carroll B. Hoffman has been named manager of The De Laval Separator Co.'s precision equipment division. In this capacity, he will be responsible, within the industrial sales division, for development and promotion of new product lines allied to the company's centrifugal equipment. He will also direct government contract and subcontract procurement.

GRANGE

HOFFMAN

Russell R. Kibbe has been appointed regional sales manager of The Texas Company's 11-state southern sales region. Kibbe's headquarters will be at Houston, Texas. He succeeds John W. Green who has been named regional sales manager of the company's 14-state northern sales region plus the district of Columbia—headquarters at New York City.

The Texas Company has completed the move to its new west coast headquarters building in Los Angeles at 3350 Wilshire Blvd.

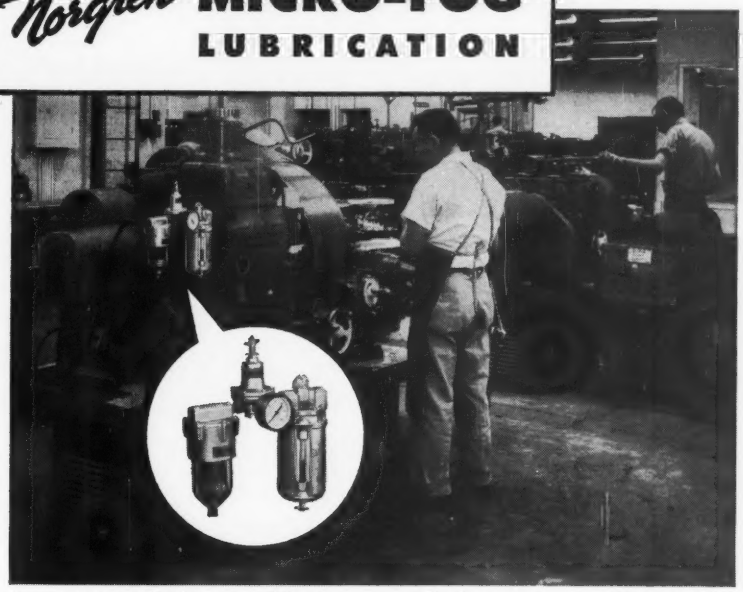
R. J. Liggett has been elected vice president and director of Tiona Petroleum Co.

The appointment of Irving P. Schwerd as chief engineer of the Belleville, N. J. manufacturing plant of L. Sonneborn Sons, Inc., petroleum refiners and manufacturing chemists, has been announced. Schwerd succeeds Herbert Goldstein who has taken an assignment abroad for Sonneborn interests.

Pfaudler Permutit Inc. has announced the appointment of J. M. Hultz as assistant to the general manager of Simplex Valve & Meter Co., a subsidiary in Lancaster, Pa. Hultz, who joined Pfaudler in June 1952, leaves his Rochester position as staff assistant to the executive vice president to take the post with the Permutit subsidiary.

Geoffrey Grange has been named sales manager for the C. A. Norgren Co. of Englewood, Colo., manufacturers of pneumatic products. For the past seven years, Grange has been managing director of C. A. Norgren Ltd., Norgren manufacturing licensee in Shipston-on-Stour, England. He succeeds Frank T. Goll who resigned in January in order to serve as Norgren district sales representative in Buffalo, N. Y.

FACTS about Norgren MICRO-FOG LUBRICATION



Norgren MICRO-FOG lubricates all bearings, gears and other components on this turret lathe.

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- ***Bearings given Ideal Lubrication***—Just the right amount of oil is applied to provide the best possible lubrication. Bearings run cooler by as much as 20° F. Bearing wear is minimized, reducing maintenance and replacement costs.
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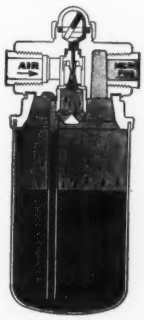

- ***Costs for Equipment are Less***—Sumps, pumps, oil filters and high pressure piping are all eliminated by MICRO-FOG, providing a big cut in equipment requirements. Also, fewer oil seals are needed, reducing costly maintenance and down-time.

A MICRO-FOG Lubricator creates an air-borne fog of extremely fine particles of oil that can be appropriately distributed to all lubrication points of even a large machine, automatically lubricating with a continuous, fully protective film of fresh, clean oil.

**Also provides ideal lubrication for gears, chains, cams, slides, ways and other machine components.*

For complete information, call your nearby Norgren Representative, or write for No. 900 CATALOG.

C. A. NORGREN CO.

If it's Norgren... It's Dependable.

3434 SO. ELATI STREET ENGLEWOOD, COLORADO

One of the heavily attended sessions on centralized lubrication. J. J. Slomer, Goodman Manufacturing Co., of Chicago, Ill. is the speaker.

About to depart on one of the tours made during the annual meeting are some of the ladies registered for the special Ladies' program. Mrs. W. E. Campbell, Chairman of the committee is shown in the dark suit (holding light handbag) at the center of the photo.

1958 ANNUAL

Scenes from the 13

Recent meeting of the Tellers Committee found Maurice Loeffel, Macco Products Co., Charles Grubert and Russel Grothus, chairman, both of Bell and Howell Co., counting ballots to determine the new directors.

J. O. McLean was presented a certificate of appreciation from the Directors and members for his work as president during 1957-58. E. R. Booser, Chairman of the Presidential Council presented the citation.

The short course in lubrication engineering attracted students from all parts of the country during the recent annual meeting at Cleveland, Ohio.

MEETING HI-LITES

th ASLE Convention

L. F. Coffin, Jr., General Electric Co., receives the *Alfred E. Hunt Memorial Award* for his paper "*Transition Temperature for Surface Damage in Sliding Metallic Contact.*"

President J. O. McLean presents the ASLE *National Award* to Earle A. Ryder for his outstanding contributions to the art and science of lubrication engineering. The award constitutes honorary life membership in the Society.

Leon Salz, Magnus Chemical Co., receives the *Wilbur Deutsch Memorial Award* for his paper, "*Choose Your Press Drawing Lubricants With Care.*"

A New Booklet:

"Industrial Dermatoses - - Protection, Prevention, and Treatment"

Donald J. Birmingham, M.D.; Dr. W. C. Witham; Leonard F. Weber; Nobel H. Schell; M. L. Beardslee; John M. Shaw, M.D.; E. A. Irwin, M.D., C. S. Livingood, M.D.

Eight experts in the field of industrial dermatitis assemble for the first time their experience and investigations in an ASLE-sponsored effort to curb these costly diseases. More than 100 million dollars in manhours are lost to American industry annually as a direct result of one or more forms of industrial dermatitis.

Five medical practitioners, a chemist, and lubrication and resident engineers examine the use and handling of cutting oils, lubricants, and solvent; and discuss protective measures in terms of ointments, housekeeping, and prevention of bacterial decomposition. While no blanket solution is agreed upon, one of the many measures outlined here may prove a solution to your specific plant problem. An informative panel discussion among all participants concludes the booklet.

Mail the coupon below for your copy.

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Please send me ( ) copies of "Industrial Dermatoses." Enclosed is my money order or check @ $1.00 per copy.

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COVER STORY

MODERN GREASE TESTING

Modern methods of testing greases have improved the products marketed for use by lubrication engineers. Some of the special tests employed by the research laboratories of lubricant manufacturers have been extended or modified to provide further information about the products prior to their release for use in industry.

To evaluate the resistance of a lubricating grease to washout by water from a bearing in the laboratory, ASTM has approved method D-1264-53T. The Water Washout Tester in the top photograph enables a jet of water to be impinged on a bearing operating at 600 rpm. The temperature of the water is held constant and tests are conducted at 100° F or 175° F.

The amount of grease washed out in one hour, under the foregoing conditions, is a measure of the resistance of a grease to water washout.

To more accurately correlate laboratory testing with actual service conditions, the working of lubricating greases before penetration tests has been extended further and further beyond the original sixty strokes prescribed by the ASTM cone penetration method of lubricating greases (D-217-52T.) The Automatic Grease Worker shown in the photograph eliminates tedious hand working and permits working greases a thousand or more strokes before penetration. The grease is subject to uniform agitation and the exact predetermined number of strokes.

This increased working, far beyond the usual 60 strokes, gives a much better prediction of the performance of the grease in actual service.

Considerable emphasis is placed upon laboratory testing of lubricants because of the constant demand from industry for improved lubrication. The current field of lubrication has accepted and is meeting the challenge to provide for the user the optimum in product results.

Cover story and photographs courtesy of The Brooks Oil Co., Cleveland, Ohio.

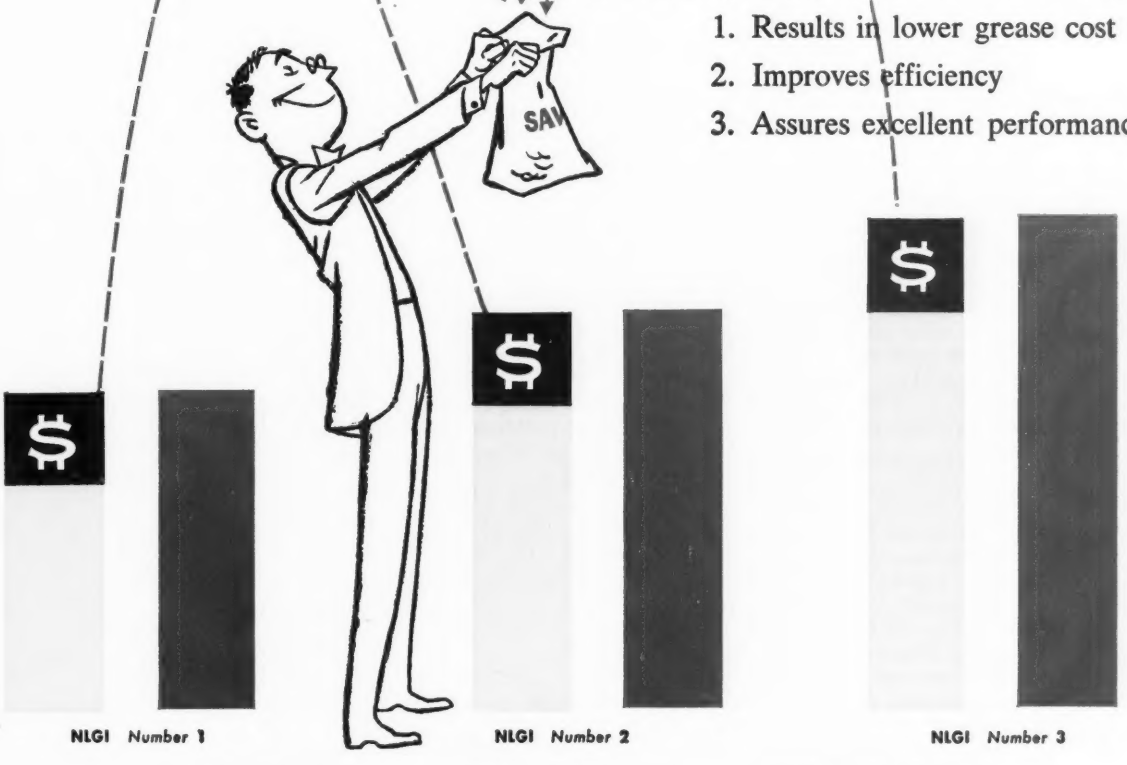
One of the 3 essentials for grease manufacturers is ECONOMY . . .

Number 2 of a series

BARAGEL* provides ECONOMY

BARAGEL provides ECONOMY because it

1. Results in lower grease cost
2. Improves efficiency
3. Assures excellent performance



BAROID CHEMICALS, INC.

A SUBSIDIARY OF NATIONAL LEAD COMPANY

1809 SOUTH COAST LIFE BLDG. HOUSTON 2, TEXAS

*Trademark of National Lead Co.

SAMUEL T. WELLMAN *was a horrified onlooker the day everything went wrong with the first open hearth furnace he had helped to build. Troubles reached their climax when the steel spilled out over molds, cars and tracks, welding everything into one mass as it chilled.*

This was in 1868. A year later, Wellman built a 5-ton open hearth furnace for the Bay State Iron Works, at South Boston. He used a much deeper bath and an arrangement of small ports, side by side with thin walls between, which gave a good mixture of gas and air. This furnace worked, and for years after produced ingots of the highest quality. It was America's first commercially successful open hearth furnace. Today, steel's greatest expansion is in open hearth capacity, increasing 36% between 1946-1955, to 110,234,160 net tons.

Great Names in Steel Making

Steel men respect success wherever met. But their special recognition is given to men and products that have helped the progress of steel.

An interesting example of this is the name "Gear Shield." In America there are mills in which the same gears have been lubricated with Gear Shield for 35 and 40 years. In consequence, the name has come to be so synonomous with satisfactory lubrication that other makers frequently refer to their lubricants as "gear shields" even though Gear Shield is the exclusive trade mark and product of The Ironsides Company.

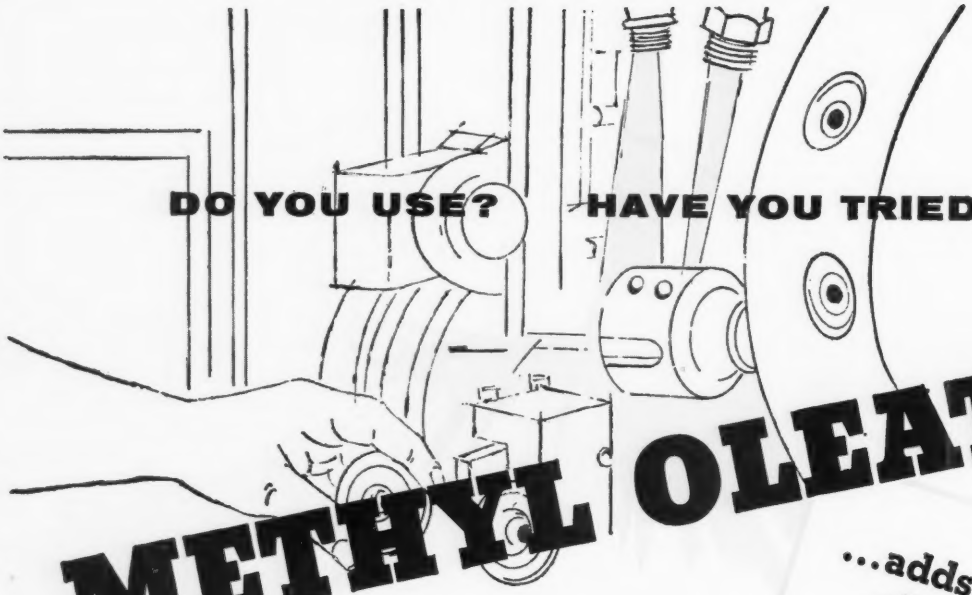
Paralleling developments in open hearth production since Samuel Wellman's first 5-ton furnace, Ironsides rolling mill lubricants have advanced far from the first heavy grease "shield," hand-paddled onto open gears. Encased gears now demand lubricants that can be poured, pumped and jetted. Free-running characteristics have become important in view of the enormous power consumption of today's big mills. At the same time, loads have increased until special Ironsides Shield is now being formulated for pressures as high as 25,000 psi. Shield for the roll necks is still being made of high melting point fatty base material, as it was 60 years ago, but is now formulated with close consideration to its pumpability. Water repellency, a consideration ever since the first rolling of hot steel, is of extreme importance in both roll neck and roller bearing shields.

In consequence, Ironsides engineers have become "custom tailors" of lubricants formulated for the specific conditions and preferences of the individual mill. They are accustomed to working closely with the superintendent, roller and lubrication engineer, on problems involving anything from a pail to tank car shipments.

If you have a problem, they'd like to help you lick it. Just address, or phone, The Ironsides Company, Columbus 16, Ohio.

By the makers of Palmoshield
"the palm tree that grows in Ohio"

Jos. MARCUL'ES.



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Other Methyl Esters. Also available are other pure methyl esters from coconut oil including Methyl Palmitate, Methyl Myristate, Methyl Laurate, and mixed Methyl Caprylate-Caprate.

SUGGESTED USES

Lube oils, cutting oils, grinding compounds. Methyl Oleate can be sulfurized to make EP additives for lube oils and cutting oils or used as is in synthetic type cutting oils and grinding compounds.

Rolling oil formulation. You will find Methyl Oleate an effective "oiliness" additive in rolling oil formulations.

Drawing oil formulations. If you would like an excellent polar additive for drawing oil and drawing compound formulations you may find Methyl Oleate your answer.

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New Products

DEGREASING EMULSIFIER ADDED BY EMULSOL

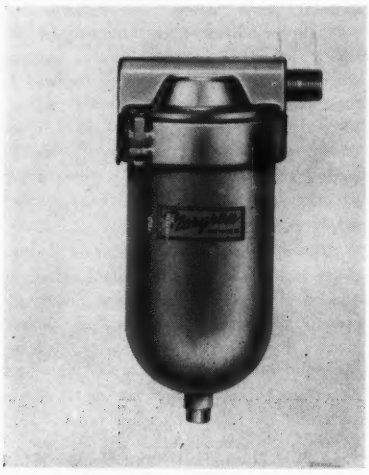
A new oil-in-water emulsifier, Emcal P-5900, shows excellent tolerance to variations in aliphatic hydrocarbon solvents. A solution of 25% P-5900 in kerosene will permit a 10-fold dilution of such aliphatic solvents as Stoddard, diesel fuel oil, and straight kerosene. The product is said to be particularly suited for use in emulsion degreasing. Finished emulsion degreasing formulations based on Emcol P-5900 have good rinsing characteristics and leave film-free metal surfaces. Good carbon and soil removal are also obtained. For more details, write Emulsol Chemical Corp., 75 E. Wacker Dr., Chicago 1, Ill.

HI-LUBRICITY BRICK GREASE

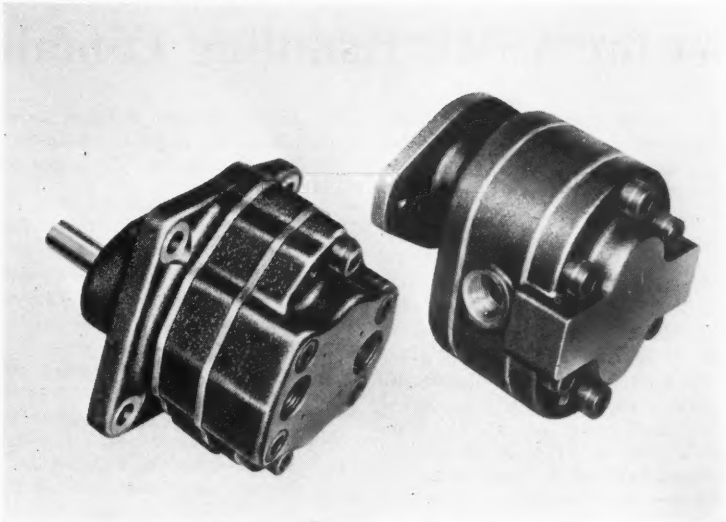
A high-lubricity brick grease for open-well, top-feed bearings is now available. Known as Keystone No. 42 brick grease, the product lubricates properly without need for either processing or frictional heat. It has a working range from 0 to 175 F and a melting point of 290 F. Its surface film is very oily and, when the brick is properly installed, provides even, ample lubrication without waste or drippage. Additional information on Keystone No. 42 high-lubricity brick grease is available from Keystone Lubricating Co., 3100 N. 21st St., Philadelphia 32, Pa.

REPLACEABLE BOWL FILTERS ADDED TO NORGREN LINE

Newly manufactured replaceable metal bowl filters offer, reportedly for the first time — improved filtering efficiency for ¾ in and 1 in. air lines where temperatures reach 200° F. and 300° F., or where pressures go as high as 250 psi. The new models, furnished with either automatic or manual drain, embody the Norgren directional louver which creates a strong centrifugal action for efficient removal of corrosive liquids from the air stream. Models with manual drain now offer improved filtering efficiency at temperatures up to 300° F. and can be used where pressures reach 250 psi. Automatic-drain models handle pressures up to 250 psi and temperatures up to 200° F. and now provide users with the advantages of standardization and stocking fewer models. Information on their complete line of filters is available from the C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

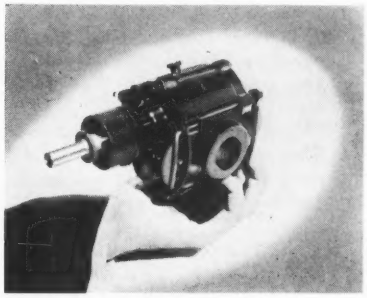


NEW POWERMAX SERIES



The Tuthill Pump Co. has announced a new series of hydraulic pumps and fluid motors for continuous service pressures to 1500 psi. Tradenamed "Powermax," these new units are issued in seven different models with pump capacities ranging from 1.2 to 14.2 gpm. Pumps and motors are provided for speeds to 3600 rpm. Both pumps and motors are of the gear type, using precision ground involute spur gears of heat treated alloy steel. Extensive field and laboratory tests have reportedly shown the volumetric and mechanical efficiency of the pumps to be outstanding. Their compact, space saving design particularly qualifies them for applications where space is at a premium. Construction features include large heavy duty anti-friction bearings, hard long wearing double wear plates of a special bronze alloy, double lip type shaft seals, generously proportioned heat treated alloy steel shaft and heavy duty outboard ball bearings for over hung shaft loads. A new catalog gives complete information and engineering data on these new units. Copies may be obtained by writing Department RP, Tuthill Pump Co., 971 East 95th St., Chicago, Ill.

HARD RUBBER GEAR PUMP HANDLES ACIDS, ALKALIES



For low-volume, positive-displacement pumping of acids, alkalies and other corrosives, the new Ace GKF gear pump features all-hard-rubber casing and gears, Kel-F bearings and rubber-covered shaft. Adaptable to many uses from laboratory work to process pumping, the pump's typical applications are handling acids from carboys and tanks, pumping from tank to process, pumping on acid tower work, and direct agitation of plating or other solutions. Discharge is continuous, positive, and in direct porportion to speed. Bearings on both the driving and driven gears are also self-lubricating to insure quiet, trouble-free operation. Motor is totally enclosed. The new pump, together with Ace plastic pipe, valves and fittings, permits complete acid transfer systems in which liquid never touches metal. Details are available from American Hard Rubber Co., Div. of Amerace Corp., Ace Road, Butler, N. J.

Cost Reduction in Recession Set for ASME Handling Confab

Such diverse topics as reduction of production costs during a recession, handling of radioactive materials, and logistics for space satellites are on the agenda of the Conference on Materials Handling.

The conference, sponsored by the American Society of Mechanical Engineers, will be held at the Public Auditorium, Cleveland, June 9-12, concurrently with the National Materials Handling Exposition.

At the show, some 200 companies will exhibit about 6,000 pieces of equipment designed to move materials by mechanical, rather than manual means. A comprehensive view of all kinds of handling equipment will be provided visitors because more than 100 different, basic types will be shown. Visitors from 25 countries are expected to inspect the exhibits.

Advance registration cards and hotel information for show and conference may be obtained from Clapp & Poliak, Inc., 341 Madison Av., New York 17, N. Y.

The program is as follows:

Monday, June 9

"Scientific Management and Materials Handling." Chairman: (To be announced later.)

"Application of Operations Research to Product Movement," by Dr. David B. Hertz, manager, operations research department, Arthur Andersen & Co., New York, N. Y.

"Automatic Techniques and Applications," by Allan Harvey, vice-president and general manager, Dasol Corp., New York, N. Y.

"Management Meets Competition Through Engineering," by Arthur Perrin, president, National Conveyors Co., Fairview, N. J.

Tuesday, June 10

"New Developments in Materials Handling." Chairman: Patrick P. Rizzo, manager of Sales, Industrial Products Engineering Co., Long Island City, N. Y.

"New Developments in Pneumatic Materials Handling — Improvements by Combination," by H. A. Markle, Jr., chief engineer, Fuller Co., Catasauqua, Pa.

"New Developments in Industrial Bulk Handling," by G. A. Tamblyn, sales manager, industrial handling equipment, materials handling division, Yale & Towne Manufacturing Co., Philadelphia, Pa.

"Operating Characteristics of the Highly Automatic Plant," by James R. Bright, associate professor, Graduate School of Business Administration, Harvard University, Cambridge, Mass.

Wednesday, June 11

"Design and Development of Special Equipment." Chairman: Carl J. Schwarzer, manager, automotive and metal working sections, industrial sales department, Westinghouse Electric Co., E. Pittsburgh, Pa.

"Development and Research in Materials Handling Equipment," by O. S. Carliss, director of engineering, materials handling division, Yale & Towne Manufacturing Co., Philadelphia.

"Design and Construction of Heavy Bulk Handling Equipment," by R. C. Tench, materials handling engineer, Chesapeake & Ohio Railway Co., Richmond, Va.

"Development of Nuclear Handling Equipment," by W. J. Dollart, application engineer, atomic power department, Westinghouse Electric Co., E. Pittsburgh, Pa.

Thursday, June 12

"Materials Handling in the Atomic and Space Age." Chairman: Erik Bergaust, executive editor, "Missiles and Rockets," Washington, D. C.

"Handling Problems with Radioactive Materials," by Frank Ring, Jr., superintendent of design, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"Materials Handling Equipment in Missile Launching," by Lt. Col. Charles M. Parkin, Corps of Engineers, U. S. Army, Fort Belvoir, Va.

"Materials Handling in Logistics for Missiles," by Michael L. Mastracci, project engineer, mechanical laboratories, American Machine & Foundry Co., Greenwich, Conn.

Conduct Research Into High Speed Bearing Lubrication

Research to develop a more fundamental understanding of the mechanisms involved in the lubrication of high-speed ball bearings is in progress at Battelle Memorial Institute, Columbus, Ohio. The study, which is being conducted under contract with Wright Air Development Center, will emphasize the role that the physical and chemical properties of lubricants play in satisfactory performance of gas turbine engine bearings.

"The lack of suitable high temperature lubricants is one of the bottlenecks in jet engine development," says W. H. Goldthwaite, head of the research team. "The research program at Battelle is designed to guide the development of new lubricants by providing basic information on the lubrication of engine bearings." This new study will attempt to correlate all information presently available on bearing lubrication—from performance data on bearings to the range of properties offered in present-day lubricants. The specialized knowledge of mechanical engineers, mathematicians, physicists, and chemists will be tapped, both within the Battelle staff and from sources in the Air Force and in industry. On the basis of this information, a group of lubricants, synthetics as well as petroleum oils, will be selected for further study. Later in the program, certain experiments with these lubricants will be designed to relate lubricant properties to performance characteristics of bearings.

Among the properties of lubricants under consideration are the variation of viscosity with temperature, pressure, and rate of shear, the density and bulk modulus, viscoelastic characteristics, film-forming behavior, interfacial tension, and corrosivity with the bearing metal, friction and wear behavior, and heat transfer and thermal characteristics.

Technologists point out that much of the past research on lubricants has concerned itself only with the study of properties of lubricants in bulk form, such as the effect of high temperatures on bulk lubricant deterioration. The Battelle team will study lubricant performance in the small, but critical, areas of near contact, where the ball "rolls" on the raceway in these bearings. This closely defined approach to the problem has been adopted on the premise that the real test of how well a lubricant serves its purpose is its performance in the region where lubrication is most critical.

"Recent advances in gas turbine power plant systems for aircraft have pointed up how much remains unknown about the critical properties of lubricating fluids," Head Researcher Goldthwaite explains. "Organic materials, upon which the bulk of lubricant technology has been based, generally are unable to withstand the high temperatures encountered in modern jet engines. Although a great deal of research is currently being devoted to developing lubricants that will hold up under this intense heat, the modest advances which have been made have sometimes been at the expense of other desirable lubricant properties."

Lube Lines

by A. F. Brewer*

RETURNS AND RESEARCH

Return on the investment as far as lubrication is concerned *depends* very largely *on research.* Appreciation of the value of research in connection with more effective usage of lubricants dates back to the early '80's and the classic studies of Beauchamp Tower, Osborne Reynolds and subsequent investigators. The idea grew with the petroleum industry, promoted in fact by mechanical developments and the extension of the intricacies of machine design. The natural sequence was the attention given to bearing metals, steel alloys, lubricant components and chemical additives. The basic objective all the while was to attain most productive machine performance.

The relation of research to the returns developed, however, can be lost sight of easily. The fact that the cost is included in the sale price of a lubricant does not help to convince the buyer that a considerable part of this price covers the research which the lubricant supplier has undertaken in order to make sure that his products are best suited to the operating conditions which may prevail. When dealing with a price buyer, it can be doubly difficult to convince him that he is paying for more than just a basic commodity — oil or grease. Whether there is merit to selling him with the aid of production cost data may be debatable. At least by showing him the proportion of the sale price which is assigned to research, a step in the right direction may be taken in weaning him away from his price complex.

PROGRESS

Research in the field of petroleum lubricants has undergone some remarkable advances over the past 20 years. Whereas the petroleum chemist used to evaluate lubricants by the customary physical laboratory tests which doubled as refinery control tests, and depend upon field performance to prove or disprove his judgement, today his laboratory facilities are virtually "goldbergian" in their intricacy. Just as his counterpart, the geophysicist, has evolved and made use of the seismograph, the gravimeter, and the magnetometer in oil field location and evaluation, so has the physico-chemist harnessed the techniques of spectroscopy, microchemistry, and radioactivity in the study of the make-up of petroleum hydrocarbons and their relation to wear or indications thereof.

The objectives are self-evident. The results are revolutionary. The benefits which accrue to management are immeasurable.

*Consultant, and author of *Basic Lubrication Practice.*

THE BENEFITS

To *management* these benefits involve greater monetary return on a machine investment when the machine parts are protected by lubricants which are so scientifically prepared as to be durable and protective even under the most exacting service conditions.

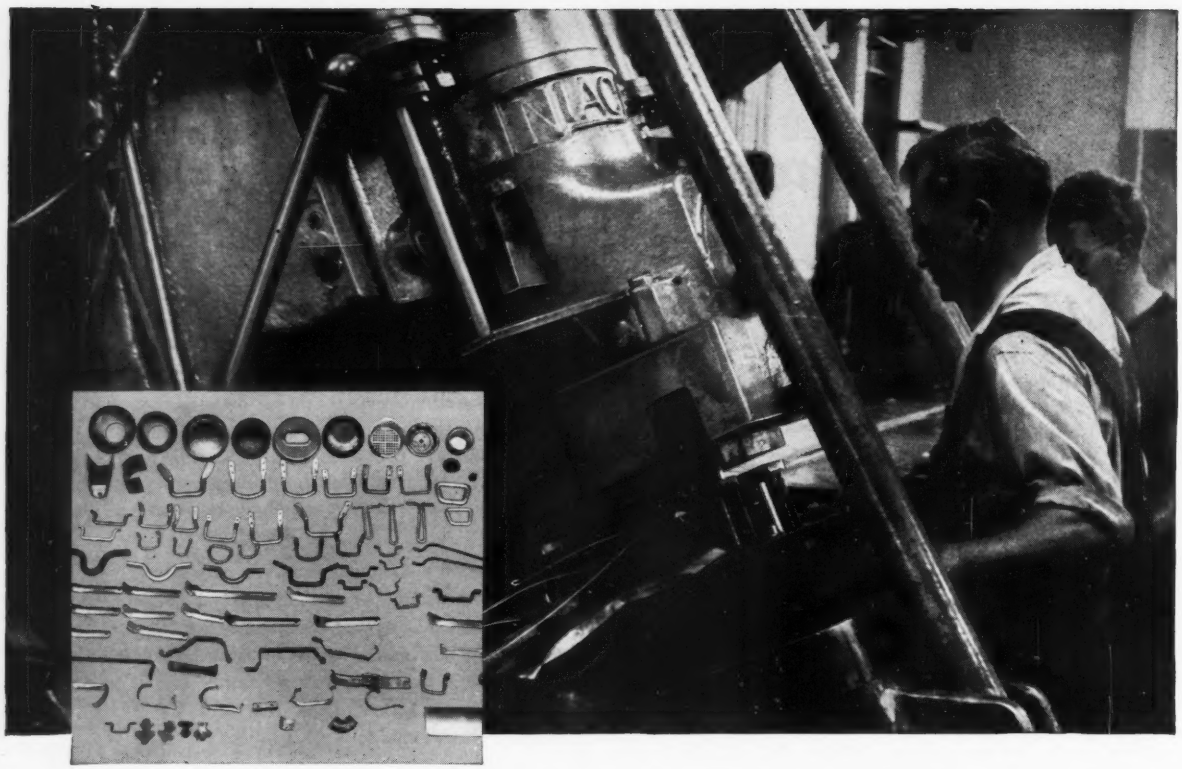
To the *petroleum researcher or physico-chemist* they present instrument methods of study which are far more precise and speedy than the conventional wet methods of handling and evaluating oil samples by test tube or fluidity procedures. In addition, the researcher can work with samples of far less volume and with more exacting control of required reactions by using modern microchemical methods of analysis.

As Related to Wear

Possibly one of the most apparent benefits of research to the lubrication engineer is involved in the study of wear. In effect, wear must be the concern of anyone who has to do with machine operation or maintenance. The most effective lubricant is the one which will most dependably prevent or reduce wear between moving parts which are in virtual contact. The organic chemist has come up with a variety of additives which will promote this objective when included in petroleum oils or greases in measured quantities which have been scientifically determined. You don't just dump in a batch of additive and hope for the best with your fingers crossed.

But some wear must be expected. We cannot hope for perpetual longevity among metals or fabrics. Research can play an important part in the study of the extent of wear by application of radioactivity. With engine piston rings, for example, this is accomplished by studying the radioactivity of the crankcase oil as induced by wear particles from radioactive rings. More recently, similar studies have been carried out on gear oils from gears which have been rendered radioactive.

It is not our intent to go into more detailed discussion of these modern tools of research. The literature is replete with scientific reports. Possibly it will suffice here to try to impress upon management that these tools are a part of lubricant preparation today, just as they are a part of the subsequent evaluation of lubricant performance and expected durability in service. Research has a decided monetary value to the consumer of lubricants which is more than justified when included in the price he pays for these products.



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RESEARCH APPLICATION EDUCATION MAINTENANCE

Journal of the American Society of Lubrication Engineers *Vol. 14 No. 5 May 1958*

Expanding Our Educational Role

Ever since the Russian sputniks zoomed into outer space, the mass media have been making us conscious of the lack of really thorough training grounds for our nation's future scientists, engineers and technicians. The first newspaper comments on the subject demanded action — eight-year-old Johnny's inability to smash the atom was deplored and denounced.

Now that our country's own satellites are in orbit, the panic-stricken voices of last November have hushed to whispers. In their place are quiet voices, judicious with the realization that American schools still have far to go in the scientific and mathematical field, but cognizant also that much good work is being done. Today, we can chuckle at the young Chicago school-teacher who is teaching her pre-first grade (1C) class about the workings of the solar system.

But the accomplishment of a few man-made moons whirling around in space should not allow us to become complacent. Somewhere between the extremes of panic and smugness lies the attitude that we as Americans and as members of a professional engineering society must take on the subject of the shortage of trained engineers and scientists.

All right, so we develop an attitude — what then? Well, the structure of the American Society of Lubrication Engineers provides an excellent opportunity for the training of future researchers. Student membership is available "to persons majoring in physics, chemistry, or engineering." How many student members are there in your section?

Those in attendance at the 1958 ASLE annual meeting heard that there was no *Walter D. Hodson award* made this year. This award is bestowed on a member 30 years of age or less for the best paper presented before the Society or published in *Lubrication Engineering*. Perhaps some of those present wondered why no such award was made. The obvious answer is that there was no qualified recipient. But beneath that obvious answer lies the deeper problem of recognizing and stimulating the interest of young engineers in the science of lubrication engineering.

That is the problem which our Society must solve. Perhaps the answer lies in a hard-sell program of obtaining more student members. Some sections have "bring-a-guest night," maybe "bring-a-student night" might be a start in the right direction (one ASLE Section invites college students to one meeting each year). Section program chairmen can easily plan such an activity.

Schools and industry are not the only training ground for future engineers. The opportunity to discuss professional problems with men who make up an engineering society such as ours should be brought to the attention of the young men who will soon be part of that profession. In return, ASLE can benefit from their new ideas. And our country can profit by having better-trained and better-informed young men ready to step into its expanding fields of technology.

A. B. Wilder, Vice President at Large

Considerations in Filter Selection

H. A. Wilson, Commercial Filters Corporation, Melrose, Massachusetts

The intent of this paper is to deal with several aspects of filter technology that are taken into account as design, test and quality control features having a distinct bearing on field performance.

The necessity of gathering factual operational data is stressed. Further, these data are weighed as to their significance and interpreted in terms of filter requirements with emphasis on performance.

The characteristics and physical considerations of certain filter media are compared. Laboratory techniques that assure predetermined filter media qualifications are explained. The entire discussion is aimed toward presenting in brief form some phases of filter technology that the lubrication engineer will find to be helpful.

These features under discussion cannot be said to be applicable only to filters for industrial lubricants. They are basic truths, having a more universal import filterwise. Moreover, although this will deal with a replaceable cartridge-type filter, the fundamental precepts have meaning in the art of filtration on a broader scale than just that encompassed by the replaceable cartridge design.

In judging filter element and container design for some specific duty, it becomes necessary first to ascertain factual operational data to provide a sure footing for subsequent selection. Assembling comprehensive valid data is not quite so simple a procedure as it might appear, although the requirements are not too involved. The important thing is to establish the accuracy of the data. All too often these data are found to be in the realm of speculation, resulting in subsequent inadequate recommendations.

What are the essential operational data that must be obtained aside from those pertaining to the manner in which the filter should be installed? Basically, they are these: rate of flow, nature of fluid to be filtered, viscosity of fluid, operating temperature, line pressure, allowable initial pressure drop, maximum allowable pressure drop, particle size removal, and nature and amount of contaminant. Other specialized considerations can and do enter the picture, but the foregoing data are the minimum needed to pursue this matter of filter selection and appraisal. Once the aforementioned operational facts have been marshalled, the ground work has been laid for sizing the filter for any particular set of conditions, having in mind some specific filter medium.

For purposes of clarity, the term *filter* is thought of as the combination of the element and the housing or casing, whereas the instrument of the actual filtration process is defined as the *element* or medium or the like. Seeing that the element is the cardinal component, subsequent comments will be confined to this area in general and the replaceable cartridge in particular. This does not mean to say that the housing is not of concern, because it is. It has to incorporate appropriate design considerations, such as, for instance, proper element seals. But it functions mainly as an enclosure for the filter medium.

FACTORS TO CONSIDER

What factors must be taken into consideration in making an appraisal of the many different kinds of available expendable elements, all having the appearance of being equally capable of satisfying the operating conditions? Principally, they are those connected with the physical traits, and it is indicated that the most significant of these are particle-size rating and efficiency, and life-expectancy as it affects the unit cost of filtration.

In correlating the physical characteristics of a replaceable element with the actualities of service, attention has to be devoted to how critical is the application. For instance, if a jet fuel filter were up for evaluation, particular emphasis would have to be placed on the examination of the element to determine its qualification with respect to channelling, rupture or by-passing. If any of these failures happen and are not noticed, the eventual result could be drastic.

Prevention of migration is another area which should be explored in judging replaceable cartridges, because of the fact that with practically all filter media, some to a greater extent than others, the possibility always exists that traces of the element itself may find its way into the filtrate.

Inquiring into the element formation with an eye to a determination of its sealing quality is advisable. Although in this association examination of the housing design particulars is in order, yet there are certain elements that have the natural property of permitting a positive seal. Specifically, the depth variety element contains this inherent feature.

The extent of the useful life of a cartridge is dependent upon several things, not the least important of which is the state of the particle retained. A blinding effect is engendered by gelatinous or slimy impurities, and the opposite phenomenon is created by granular substances which have a propensity of forming a filterable layer on the element surface. Both the shape and state of the contaminant are relevant to length of service. Cer-

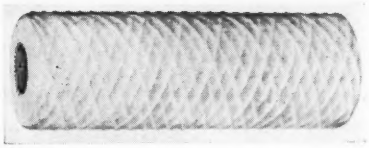

Figure 1.
Depth-type filter element.

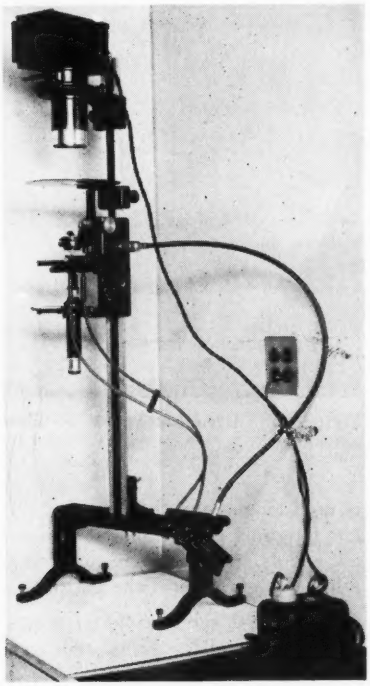

Figure 2.
Microprojector.

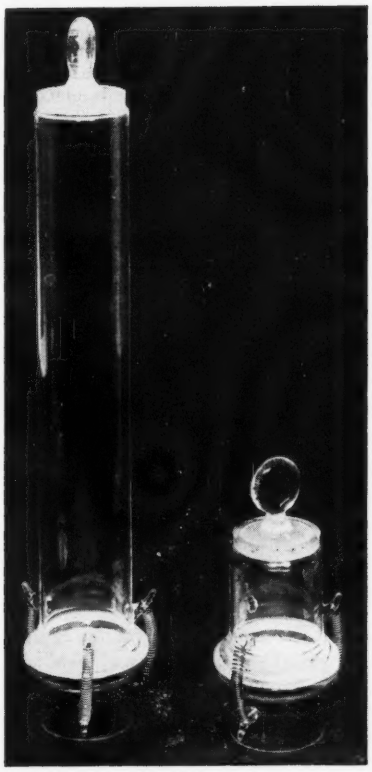

Figure 3.
Particle size cells.

tain shapes incline toward sustaining porosity, developing a situation conducive to extending useful life.

Even so, cartridges can differ markedly in their life cycle when compared under any fixed set of conditions. In essence, this stems from the difference in materials that go into the makeup of the cartridge, the reaction of the materials to the effects of the influent and contaminants, and the shape in which the various materials can be formed. The extended area paper element is considered to have relatively good dirt storage capacity for the reason that comparatively larger amounts of surface area can be compacted into a comparatively small space by means of developing distinctive configurations. The pleated paper element is one such development. Of course this business of element life is closely associated with unit cost of filtration, and the corollary is that accurate evaluation is the key to minimum cost.

PARTICLE-SIZE RATING OF ELEMENTS

Inasmuch as the principal function of an inert filter element is predicated upon removing from the stream solids in size larger than a predetermined dimension, the rating of an element for particle size assumes a high degree of importance. Because it is of such consequence, detailed treatment is indicated. The recognition of the meaning of particle-size ratings — how and under what circumstances they are made — how they relate to the application on hand — and their reliability — is of material interest to anyone called upon to make recommendations of filtration equipment for reasons of protecting adjacent moving surfaces in machinery.

To express retentivity in terms of particle-size without reference to the ratio retained relates only half the story and leads to misconceptions. Stating claims like, "This element will remove particles down to one micron," or "That cartridge removes particles in the micron range," is meaningless unless accompanied by the percentage of one-micron particles removed in the first example and the percentage and size in the second. No matter what its porosity may be, any element will retain a certain amount of suspended particles one micron in size. Only one properly engineered will remove those impurities to a desirably high degree of clarity within the confines of its specified rating.

Another facet of this matter of element particle-size rating from the practical side is brought out by citing the experience of an aircraft company. While making a test run on a certain element claimed to possess a 10-micron retention property, it was discovered that the element itself was a source of resin particles 40-microns and larger which were shedding into the stream. Such being the case, the element proved to be unsatisfactory for it was intended for use in a system where clearances were in the order of 0.0003 to 0.0004 inch.

DETERMINATION OF PARTICLE-SIZE RATINGS

How applied filter technology, which deals with all phases of the art and is concerned with media, element formations, fabrication, quality controls, laboratory techniques and so on, is utilized can be illustrated by describing a laboratory procedure developed by the author's company for the determination and verification of particle-size ratings of one of the elements of our manufacture.

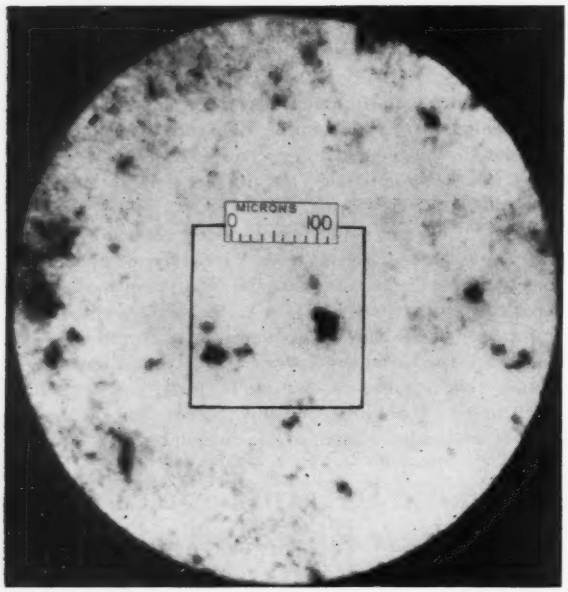

Figure 4. Microphotograph of unfiltered particle-size evaluation sample (scale in microns).

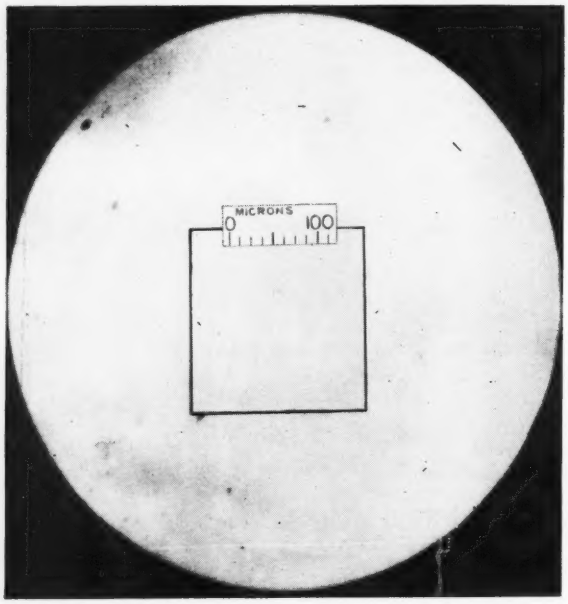

Figure 5. Microphotograph of filtered particle-size evaluation sample.

There are two methods by which particle-size ratings are established. The first and most widely used is called a microscopical counting method of evaluating element particle-size retention. The second determines the pore size distribution of the media.

The microscopical counting procedure is generally as follows: A contaminant of known size distribution and physical properties is added in predetermined proportions to a fluid of known viscosity, and the uniform suspension is forced through a filter medium. Unfiltered and filtered samples of the contaminated mixture are taken and representative microscopic slides prepared. The number and size of contaminant particles of the filtered and unfiltered samples are counted, after which a mathematical relationship is set up between such factors as number of particles counted, area of field, total fields counted, etc., giving the efficiency of removal at various micron levels.

The pore size distribution method differs in that an analysis is made of the size and distribution of the pores. This is accomplished by forcing a fluid under pressure into the medium. From an equation which relates pressure and pore radii in microns, the distribution and size of pores may be measured. This method of element rating is extremely useful for the surface and semi-depth type of media but is not adaptable to the true depth-type at present.

Currently, both methods are used by the author's company. Figure 1 shows a depth-type element of a certain porosity. Because it is of the depth-type classification, the particle size rating is evaluated by means of the microscopical counting method which is described subsequently.

Figure 2 shows a microprojector used to project the slide, bearing the contaminant to be counted and measured. Usually a magnification of 500 diameters is employed. A scale graduated in 5-micron intervals, or in intervals consistent with the size of particles to be counted, is used to measure the particles. The microprojector is less fatiguing for the analyst who must perform these visual counts and measurements, and yet does not result in a loss of definition of the particles.

Figure 3 shows singular pieces of apparatus called particle-size cells. These cells are used because it is possible to perform all pertinent operations without any attending transfers or dilutions of sample, thereby eliminating these potential sources of error. In addition, a uniform distribution of particles is obtained on the absolute filter membrane capable of removing all particles in excess of ½ micron. The membrane with the particles distributed on its surface is placed in the microprojector and observed visually.

Figure 4 illustrates a projection of the contaminant from a typical inlet or unfiltered sample ready to be counted.

Figure 5 shows a projection of the contaminant and reduction in particle count and distribution after the sample had been put through a filter element capable of removing 10-micron particles.

Figure 6 is a graph of two curves, No. 1 for nonaqueous and No. 2 for aqueous solutions, obtained by plotting the findings from the described element rating procedure. By referring to either curve, the element of a design shown in Figure 1 can be selected with the necessary porosity, to provide the required particle size removal to an efficiency of at least 90 percent.

SUMMARY

The trend in filtration, of necessity, is toward removal of smaller and smaller particles as clearances continue to shrink. All other things being equal, it is generally true that filtration cost is in inverse ratio to the

(Cont. on p. 220)

Plastics as Solid Lubricants and Bearings

A. J. G. Allan, Research Division, Polychemicals Department,
E. I. du Pont de Nemours & Company, Inc., Wilmington, Delaware

Recent studies on the fundamental aspects of friction and wear of plastics are reviewed with particular reference to polytetrafluoroethylene. It is suggested that differences reported in the friction of polytetrafluoroethylene may be related to differences in the mechanism of shearing at the areas of intimate molecular contact. A review of wear data shows that the wear of polytetrafluoroethylene depends markedly on conditions of load and speed and the presence of fillers. It is possible that these differences in wear are related to the differences in friction. In conclusion, some applications of polytetrafluoroethylene and nylon bearing surfaces are described in relation to the physical characteristics of the materials.

INTRODUCTION

It has often been pointed out that much of our modern daily life is only possible by use of the machine which means, in effect, by control of the forces arising when one surface slides over another. In recent years, high polymeric materials have found their way into more and more mechanical applications. Ease of fabrication, low density, and resistance to corrosion have been major factors influencing the general progress of plastics in the engineering field. As the applications have become more varied, the surface properties and, in particular, the frictional properties have attracted considerable interest. In bearing applications, a satisfactory lubricant or solid bearing must reduce friction, but more important it must eliminate wear for a long time and require no maintenance; that is, it must itself be resistant to wear. These general requirements of a lubricant or bearing material are becoming increasingly stringent as modern machinery is operated under extremes of climatic conditions. The conventional oils and greases suffer from certain inherent disadvantages requiring a high level of maintenance under any change of climate from those for which the lubricant was designed. For these reasons, there has been a great deal of interest in solid or dry lubricants and in bearing surfaces of unlubricated or initially lubricated high polymers.

The purpose of this paper is to review our present knowledge about friction in plastics, to mention some aspects of current wear theory applied to plastics, and to give some particular examples of dry lubrication and the use of plastic bearings.

APPLICATION OF THE THEORY OF FRICTION TO PLASTICS

As a logical extension of their theory of metallic friction, Bowden and Tabor and their colleagues have related the friction of plastics to the bulk properties, shear strength and hardness (1). At the same time Zisman and his coworkers, with an interest in lubrication problems, have studied the frictional properties of plastics with particular emphasis on the chemical nature of the surface (2). From these rather different viewpoints we have some understanding of the interrelationship between friction of plastics and the bulk and surface properties. However, little is known about boundary lubrication of plastics and the use of plastics as bearing surfaces has only been studied very empirically.

The basic mechanism of friction is now well established, particularly for metals. It is known that when two surfaces are placed together intimate molecular contact occurs only at the tips of the asperities in the surface (3). These asperities are then deformed until the area in contact A is sufficient to support the load W. Over the contact area thus formed there is marked molecular interaction so that a cold weld or junction is formed comparable in strength to the bulk of the material forming the junction. In sliding the surfaces relative to one another tangentially, a certain force F is required to shear these minute junctions. This mechanism is described by the well-known equation

$$F = As = \frac{Ws}{p_m} \qquad [1]$$

where s = the shear strength of the junction
p_m = the yield pressure of the material.

This basic concept has been developed for a variety of materials, metals and nonmetals, elastic, plastic and brittle solids. It is not surprising that such a simple model has to be modified in any particular instance, but all the available evidence indicates that the fundamental idea is correct: namely, the force of friction arises from the making and breaking of areas of molecular contact generally much smaller than the geometrical area of the specimens being rubbed together.

The way in which equation [1] has to be modified in a particular case depends on the way in which A, s, and p_m vary with load and the conditions of sliding. Also, in the particular case of a hard material sliding on a soft one, there is a significant contribution to friction by the plowing out of the softer material (4). This contribution of the plowing to the total friction in such cases has recently been measured by Spurr (5).

The extensive literature on the friction and lubrication of metals has been reviewed previously in this journal (6, 7). However, it seems of interest to discuss some of the more recent work on metals, emphasizing the ways in which current ideas have to be modified for plastics.

In the case of metals in sliding contact, the shear strength calculated from the friction equation [1] is appreciably larger than obtained by direct measurement. McFarlane and Tabor (8) showed that this is due to the interrelationship of normal and tangential stresses which produced junction growth. When the specimens are under normal load, the smallest tangential force causes a microdisplacement and the contact area increases. This was also observed by Parker and Hatch (10). It follows from this, however, that as the tangential force is increased, the junctions should continue to grow with seizure rather than sliding. To explain the steady sliding of unlubricated metals, Green (11) pointed out that junction growth must be partially prevented during steady sliding because no appreciable normal displacement of the plane of sliding is allowable. Experimental tests of Green's theory by Greenwood and Tabor (12) using macroscopic junctions showed that there was good qualitative agreement, but coefficients of friction of the order $f = 1$ were obtained only for the two piece junction designed to represent weak adhesion. This confirmed the frequently mentioned idea that the friction generally observed for clean metals in air is due primarily to the presence of oxide films. Values comparable with those of Green's theory and Greenwood and Tabor's "ideal" or single piece junction are only obtained when metals slide in vacuo. For example, recent studies by Bowden and Rowe[13] illustrate complete seizure when oxide films are removed and junction growth is permitted.

In studying lubricant films with similar two piece macroscopic junctions Greenwood and Tabor (12) found an increase in coefficient of friction with the angle α between the interface of the macroscopic junction and the sliding direction for all junctions other than the single piece junction. It is important to note that in the case of the solid lubricant, polytetrafluoroethylene, the increase in f due to the increase in α was not due to increased metallic contact since the electrical resistance remained infinite throughout the deformation. Thus, the increase in f with α was attributed to the work done in gross deformation of the junction. This is an important observation, since it means in practice that metal surfaces adequately protected by a lubricating layer of polytetrafluoroethylene will not come into contact and thus, on prolonged sliding, there will be no wear at all unless the protecting layer of polymer is itself worn away.

It is clear that metals are protected under all normal sliding conditions by a layer of oxide which acts as a very poor dry lubricant by preventing metal-to-metal contact. The function and properties of the oxide layer were reviewed by Finch (14). In the case of plastics, however, there is no such dry lubricating layer of oxide, and we might expect the effect of sliding conditions on plastics to be different from the effect on metals.

The first problem in the friction of plastics is to find out if the basic mechanism is similar to that for metals. Extensive studies (2, 15, 16, 17, 18) have indicated that equation [1] is approximately correct over a restricted load range, but studies over a wide range of loads show that with polymers the friction does not increase linearly with load so that the coefficient of friction decreases as the load increases (17). This effect has been most noticeable in studies of friction between fibers at low loads (19) where one might expect contact to be restricted to an area almost equivalent to the geometrical area. Various studies have emphasized three conflicting ideas. First, it has been suggested that the friction at low loads is due to elastic deformation while at high loads the deformation is plastic in nature (20, 21). Secondly, recent work by Pascoe and Tabor (22) has shown that it is unlikely that the deformation changes from elastic to plastic, one law of deformation explaning the change in coefficient of friction with load over a load range of 10^{-6} to 10^{+4} g. Finally, Archard (23, 40) has suggested that it is unnecessary to require anything other than purely elastic deformation, since the multiple point contact introduced by the large number of surface asperities normally found on flat surfaces causes the frictional force to become nearly proportional to the load and give f vs. W relationships similar to those found by Pascoe and Tabor.

More detailed studies of individual types of plastics reveal differences in friction between plastics which can be explained in terms of the bulk properties, shear strength, and hardness. However, one notable exception is polytetrafluoroethylene, which is quite anomalous in its behavior under slow speed sliding conditions. While other plastics give values of f and s/p_m in agreement within a factor of two, (17, 18) f generally being higher, polytetrafluoroethylene gives values of f two or three times lower than that anticipated from a calculation of s/p_m. This unusually good frictional property has led to the extensive application of coatings of TFE-fluorocarbon resin to problems where low adhesion and friction of touching surfaces are required. The low friction of polytetrafluoroethylene is discussed in detail below.

THE NATURE OF WEAR

The importance of wear in mechanical applications of plastics is well known, but the process of wear is not understood. The work of Hirst, Archard (24, 25) and their colleagues (26) has recently shown that there is probably a simple law of wear analogous to the law of friction $F = fw$ of the form $V_w = KW$, where V_w = volume of material worn away per unit sliding distance, W = load on the specimens and K a "coefficient of wear". It also seems likely that this simple law, again like the law of friction, requires some modification in particular instances. It is evident from these studies that under appropriate conditions the wear rate is independent of the area of contact and is proportional to the load, and there are two types of wear, mild and severe. The two types of wear are associated, in the case of steel, with two mechanisms, the mild wear involving only oxide formation, while the latter involves the production of largely metallic, oxide-covered fragments of metal. The elegant studies of Kerridge and Lancaster (26) have shown that in the severe wear process the size of the wear particle is directly proportional to the load. Since it was shown earlier (3) that the area of real contact between surfaces is proportional to the load, this work provides important experimental confirmation that both friction and wear arise by welding at the small areas of intimate molecular contact between rubbing surfaces.

While much of this work on wear has been devoted to studies of metals, some data for plastics have been given (25) and, in practical tests, nylon has been found particularly wear resistant in many bearing applications, although the friction may not be as low as with some other materials.

It seems reasonable to suppose that much of the work on metals can be applied to plastics if we bear in mind the differences in properties which are important in any particular set of circumstances. The effect of heating and softening of the interface is particularly important and, under extreme conditions, the nature of the wear products must be considered.

FRICTION AND WEAR OF POLYTETRAFLUOROETHYLENE AND NYLON

The good frictional properties of polytetrafluoroethylene and the high wear resistance of nylon have been responsible for wide applications of these plastics. Polytetrafluoroethylene has been found excellent for friction reduction, particularly under moderate loads and low speeds, but is often not wear resistant enough unless a reinforcing agent is used. Nylon is very durable for high loads and low speeds, but unlubricated bearings may squeak and sometimes have a high friction. It is interesting to apply some of the current ideas on friction and wear to these two materials, particularly polytetrafluoroethylene.

POLYTETRAFLUOROETHYLENE

It has been firmly established that polytetrafluoroethylene has an unusually low friction under slow speed sliding conditions, similar to metals covered with a film of lubricant (17). It was shown by King and Tabor (18) that surface films are absent in the case of polytetrafluoroethylene, so that the low friction can only be attributed to a basic property of the polymer. Shooter and Tabor (17) suggested that the effect is due to the inherently low cohesive forces between adjacent polymer chains. Although the carbon-fluorine dipole is large, the comparatively large size of the fluorine atoms will effectively screen the dipole (38). This screening action reduces the molecular cohesion so that the specific shearing force at the interface is low while the bulk shear strength remains higher since it depends more on the interlocking of molecular chains, the degree of crystallization and the efficiency of the sintering process.

Recent work (27) has shown that treatment of the surface layer of TFE resin by the formation of a relatively polar surface film for adhesive purposes results in an increase in the friction to a value in good agreement with bulk properties. This suggests that in such circumstances the surfaces can form a strong weld, and the junctions shear in the bulk rather than at the interface.

The bulk properties of polytetrafluoroethylene are still of considerable importance even when shearing occurs at the interface. For example, production of a harder resin would lower the coefficient of friction, since the effective shear strength is constant.

Even under slow-speed sliding conditions there have been reported widely different values for the coefficient of friction of polytetrafluoroethylene (2, 17, 18, 28, 22). Bearing in mind the errors incorporated by ignoring the radius of curvature of the contact areas and the occurrence of multiple point contact at higher loads, the results collected in Figure 1 show that the differences in the literature can be reconciled for loads from 10^{-6} to 10^{+6}g, the coefficient of friction varying by a factor of 50 over this load range (Figure 2). This is important in practice, since it suggests that polytetrafluoroethylene is incapable of seizure under extremes of loading. This complete absence of seizure was observed by Shooter and

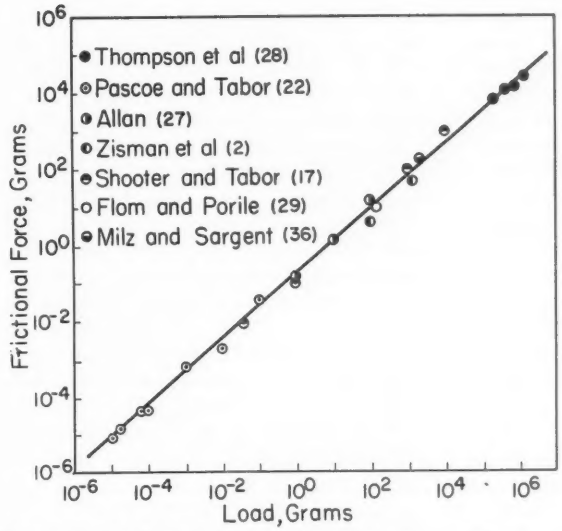

Figure 1. Collected data showing the effect of load on frictional force for polytetrafluoroethylene (on a logarithmic scale).

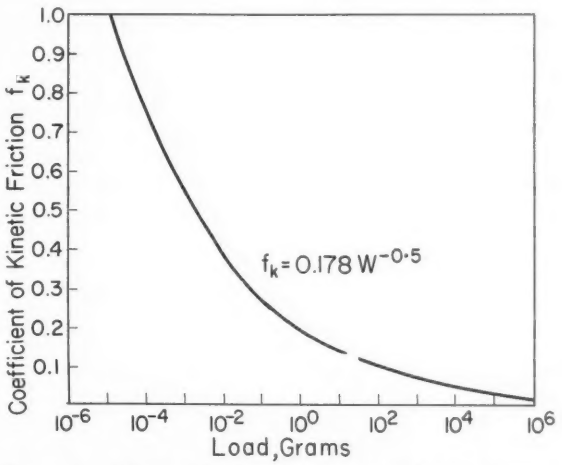

Figure 2. Effect of load on coefficient of kinetic friction from data in Figure 1.

Thomas (15), who were not able to friction-weld polytetrafluoroethylene at high loads and speeds even though the interface rose well above the decomposition temperature.

The effect of ambient temperature and sliding speed on the friction and other properties of polytetrafluoroethylene is receiving increasing attention. With a stationary pin and rotating cylinder similar to a conventional pin and ring wear tester, Flom and Porile (29) found the customary low friction ($f_k = 0.1$) was only obtained at slow speeds with fresh surfaces. High-speed sliding caused a rise in f_k to 0.4 and in subsequent slow-speed sliding of the worn surfaces f_k was never lower than 0.19. Also, a marked decrease in the friction occurred as the temperature was lowered below the 20°C transition temperature. It is important to note that this latter effect was obtained with the worn surfaces. With fresh surfaces, no such transition was reported (18). In the absence of more explicit evidence we may suggest that there are possibly two mechanisms operating. In the case of high-speed sliding above the transition temperature, the joint formed at the interface is strong enough

to cause shearing in the bulk rather than at the interface. In the case of high- and low-speed sliding below the transition temperature, the shearing of junctions occurs predominantly at the interface, the difference between $f_k = 0.1$ for fresh surfaces at low speed and $f_k = 0.2$ for worn surfaces being due, as Flom and Porile suggest, to changes in the bulk properties of the specimens by the previous high-speed heating cycle. This is extremely speculative and requires experiments over a much wider temperature range than that studied by Flom and Porile. It would be particularly interesting to see if, at low enough temperatures, sliding at high speed produces coefficients of frictions as low as 0.1. It should be noted that the technique of preparation of the sample, particularly its thermal history, can have an important effect on the bulk physical properties (30).

We might expect differences in the mechanism of friction to have an important effect on wear. It has been reported that the wear of polytetrafluoroethylene is considerably higher than a softer polyethylene[25], but there is little other published information. Several simple bearing tests were made in this laboratory using conventional bearing testing apparatus and measuring the weight loss under several loadings. The results of these tests together with the results of Archard and Hirst and some experiments with a loaded abrasive wheel (31) are shown in Figure 3. Data by White (32) and by Flom and Porile (29) are also shown. It can be seen that the filled bearing of White represents wear rates over two orders of magnitude lower than the rest of the data. These data again are inadequate for more than speculation, but they do suggest that there may be both mild and severe

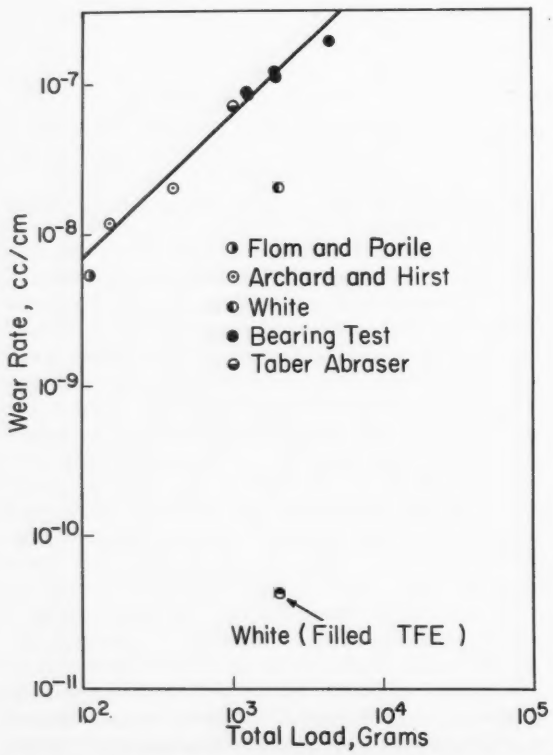

Figure 3. Collected wear data showing the effect of load on the volume worn away per unit sliding distance.

wear conditions possible for polytetrafluoroethylene depending on the hardness (presence of fillers) load and sliding speed. It is desirable to examine more thoroughly the wear process in polytetrafluoroethylene using a range of load and sliding speeds.

Recent work by Zisman et. al., (37) has shown that thin coatings of polytetrafluoroethylene on metal substrates have important applications, partly because the surface temperature is lowered by the enhanced thermal conductivity, but mainly because the hard substrate is better able to support the load. In other attempts to achieve the thermal and mechanical properties of metal while maintaining the frictional properties of polytetrafluoroethylene, porous metal bearings filled with polytetrafluoroethylene have been made. Data were presented in 1952 showing that the endurance of such bearings greatly exceeded that of similar bearings filled with conventional oils (33).

Because of high wear the present varieties of unfilled solid polytetrafluoroethylene are not suitable for use as a bulk bearing material under severe conditions (for example, when the product of the pressure in pounds per square inch and surface speed in feet per minute exceeds 1000) (35). On the other hand, as a thin coating, or as a fiber, or the major or minor component of a filled bearing, polytetrafluoroethylene offers outstanding properties, particularly since the wear products at high temperatures do not destroy its good frictional properties.

Future studies of the use of polytetrafluoroethylene as an engineering material, particularly as a bearing, should be directed toward achieving the optimum bulk properties. In this connection, some interesting work on a fabric of TFE-fluorocarbon fiber should be mentioned. By means of novel extrusion techniques, it has been possible to produce strong fibers of polytetrafluoroethylene which can be woven into a fabric and used as a bearing surface. The hard, tough fibers are much more resistant to abrasion and cold flow while the outstanding frictional properties of the polytetrafluoroethylene are retained. For example, experiments have been made with journal bearings that incorporate a fixed layer of fabric of TFE-fluorocarbon fiber on a thermosetting plastic housing. Fixed-surface bearings of this type compared favorably with oil impregnated porous bronze and strip-type nylon bearings. In an experiment with 1 x 1 inch sleeve bearings, initially lubricated only and shaft speed 50 feet/minute, both bronze and nylon bearings failed at 675 pounds load (*PV* 34,000) while the bearing of TFE-fluorocarbon fabric was still undamaged at 925 pounds (*PV* 46,000) and was stopped only because the temperature was 300°C which is probably higher than would be considered acceptable for most uses (39).

Nylon

Although it can hardly be regarded as a solid lubricant, nylon has found wide application in gears and bearings because of its excellent wear resistance. As with most materials, it is advantageous to lubricate nylon. Zisman reports that it is difficult to find a satisfactory boundary lubricant under slow-speed sliding conditions (34). At the same time, extremely good results have been obtained with high-speed sleeve bearings and bushings of nylon (35). After a period of running under lubricated conditions the oil supply was stopped so that the latter part of the run was made with effectively initial lubrica-

tion only. The bearing performance remained surprisingly good. It is thought that the deformation characteristics are such that the lubricant is held in the center of the bearing and cannot leak out at the edges.

The coefficient of friction vs. load relation for dry nylon was obtained by Pascoe and Tabor (22) over the load range 10^{-6}g to 10^{+4}g using crossed fibers and cylinders so that well-defined contact areas were obtained. It was found that the coefficient of friction decreased with the load so that relatively low values ($f_k = 0.15$) are obtained at high loadings. This may be related to the exceptionally good wear resistance of nylon.

Detailed data on the wear and friction of nylon and TFE-fluorocarbon resin are given in the comprehensive paper by Cheney, Haddoldt, and Swayne (35). These authors also present collected information on the bulk properties of commercially available nylon and polytetrafluoroethylene which are important in bearing applications.

Summary and Conclusions

A review of our present knowledge of friction and wear shows that the mechanism for plastics is similar to that for metals, differing in detail because of the differences in the chemical nature of the surface and the changes in bulk properties which affect deformation under specific sliding conditions. This applies typically to nylon. Polytetrafluoroethylene, on the other hand, is an exceptional material, and a detailed account of the friction and wear implies that an additional factor is involved in the sliding mechanism; namely, failure at the interface rather than in the bulk of the material. The latter mechanism predominates under slow-speed conditions on unmodified polytetrafluoroethylene. When the material is appreciably heated under the conditions of test or use, the conventional welding mechanism predominates and polytetrafluoroethylene loses its remarkable self-lubricating property to behave like any other plastic, but still retaining good bulk properties to a much higher temperature.

Very interesting developments in bearing performance may come from the use of polytetrafluoroethylene in various forms. As thin coatings, as fibers, impregnated in metals and with reinforcing agents, polytetrafluoroethylene can be processed in many ways to exploit the unusually low friction, inertness and high thermal stability of this plastic.

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Effect of Capillary Length-to-Diameter Ratio on Grease Viscosity

W. R. Miller, T. J. Walsh**, and R. R. Slaymaker****

Seven greases were tested in a capillary tube viscosimeter in order to study the effect of capillary length to diameter ratio on their apparent viscosity. All greases were tested at 75°F, and three were tested a 40°F. A change in apparent viscosity occurred in all greases for capillary length to diameter ratios of 250:1. Beyond this point there was little change in apparent viscosity, with the exception of grease E which exhibited a change to ratios of 1000:1. Reducing temperature increased the change in apparent viscosity for two given capillaries at a constant shear rate.

NOMENCLATURE

τ = Shear stress $\frac{PR}{2L}$, lb/in.^{2}
L = Length of capillary, in.
P = Pressure, lb/in.^{2}
Q = Volumetric flow rate, in.^{3}/sec
R = Radius of capillary, in.
μ = Apparent viscosity, lb sec/in.^{2}

A capillary tube viscosimeter was used with capillaries having length to diameter ratios of 40:1, 100:1, 250:1, 500:1, and 1000:1. The viscosimeter, housed in a temperature chamber, was operated much as described in previous papers (3). The instrument was modified by removing the piston and using nitrogen rather than oil as the motivating fluid. The operation differed only in that it was necessary to completely flush the capillaries at each shear rate before taking a reading, a procedure which Wilson and Smith also followed.

The equation used in the treatment of the data was first proposed by Rabinowitsch and later developed as part of Mooney's equations (4)†. This equation is given as

$$\frac{\tau}{\mu} = \frac{1}{\pi R^3}\left[3Q + \tau\frac{dQ}{d\tau}\right]$$

Three of the seven greases, A, B, and C, were experimental, while the other four, D, E, F, and G, were commercial greases commonly used in centralized lubrication equipment. Unfortunately, complete specifications of the commercial greases could not be obtained. Table 1 gives the available specifications of the greases, while Table 2 gives data at shear rates of 10, 50, and 100 reciprocal seconds for capillary 40. Data in Table 2 also compare the change in apparent viscosity between capillaries 40 and 250 at constant shear rates. Tables 3 through 8 contain capillary data and complete experimental data for three of the greases. Data on the other greases may be obtained by writing to the authors. In the discussion to follow, the percentage change in apparent viscosity at constant shear rates will be between capillaries 40 and 250.

Manufacturing progress over the years has made heavier demands upon lubrication equipment and techniques, which has resulted in increased use of centralized lubrication systems. These systems service from a few to several hundred bearings and may be operated by a simple hand pump or, for large systems, an elaborate motorized pump controlled by pressure and timer components. Although these systems reduce the human element to a minimum and assure more uniform lubrication, they also emphasize problems resulting from the physical characteristics of the lubricating fluid. A lubrication engineer must choose a lubricant which will satisfy bearing requirements and still be compatible with his lubricating system, even though the system is required to operate over a wide range of temperatures. Under these conditions, viscosity data are useful tools for the lubrication engineer.

TABLE 1. GREASE DATA

Grease	A	B	C	D	E	F	G
Soap, % Wt.	26.10	19.40	19.05	4.7	11.5	4.5-5	5-7
Oil, % Wt.	72.60	79.40	79.60	—	—	—	—
Soap Type	Na	Na	Na	Na	Na	Na	Li
Penetration							
Unworked at 77°F	290	322	350	310	280	—	320
Worked at 77°F	300	340	360	330	285	—	310-340
Drop Pt. °F	400	400	400	—	420	—	350
Oil Properties							
Gravity API	29.9	29.9	29.9	—	—	—	—
ssu at 100°F	440	440	440	4213	1412	1200	—
ssu at 210°F	60	60	60	179	92	—	75

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Editor's Note: The viscosity calculated from Mooney's equation is the viscosity at the capillary wall. The authors call this an apparent viscosity. This usage is different from the commonly accepted one where apparent viscosity is calculated from Poiseuille's equation for flow in a capillary.

Much of the viscosity data available for greases have been obtained with a capillary tube viscosimeter having capillary length to diameter ratios of less than 100 to 1. This allows one to compare the viscosities of several greases when tested under identical conditions, but it does not necessarily tell how they will perform in lubrication systems of various lengths. This question has been asked on numerous occasions, both by users and manufacturers of lubrication equipment. A search of the literature revealed only two papers on the subject (1, 2). One group operated at shear rates much higher than found in centralized systems, while the other group used greases which their critics felt were not representative of commercial greases. The work upon which this paper is based was done at shear rates approximating those in centralized systems.

All of the greases except grease G had sodium soap in amounts from 4.5 percent to 26.1 percent and base oils ranging from 440 to 4200 saybolt seconds at 100°F. Greases A, B, and C had 26.1 percent, 19.4 percent, and

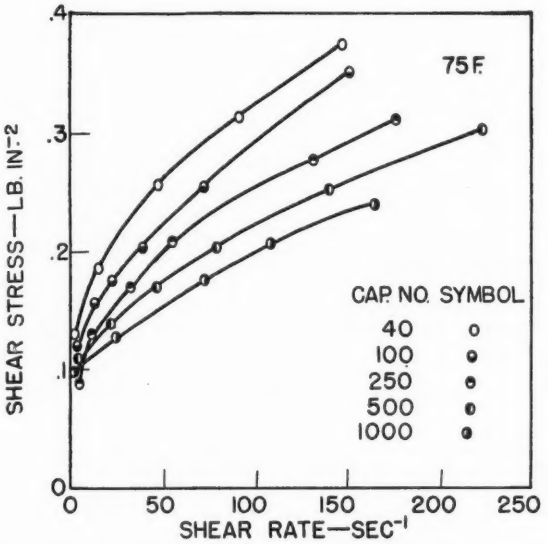

Figure 1. Shear stress vs shear rate for grease E.

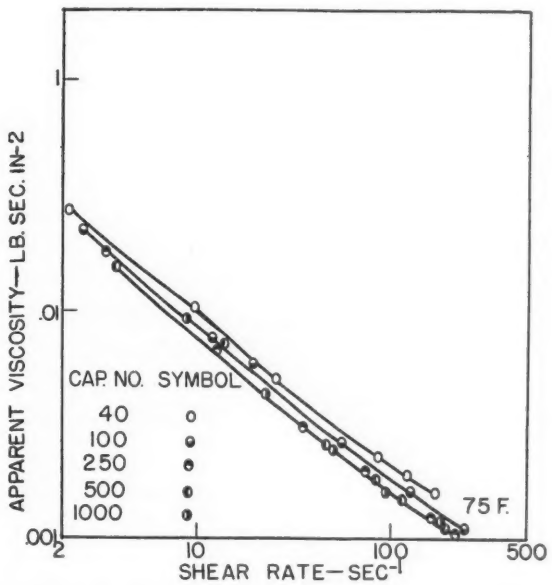

Figure 2. Apparent viscosity vs shear rate for grease A.

TABLE 2. PERCENTAGE CHANGE IN APPARENT VISCOSITY

% Change in μ, Cap 40-240 75°F	% Change in μ, Cap 40-240 40°F	Shear Rate Sec^{-1}	Apparent Viscosity, Cap 40 75°F	Apparent Viscosity, Cap 40 40°F	Grease
14.0	—	10	0.01000	—	
16.1	—	50	0.00310	—	A
19.2	—	100	0.00198	—	
13.6	22.3	10	0.00405	0.00960	
15.4	27.4	50	0.00136	0.00365	B
17.0	27.7	100	0.00094	0.00255	
12.7	19.2	10	0.00218	0.00545	
14.9	26.0	50	0.00084	0.00248	C
16.8	27.1	100	0.00063	0.00192	
23.4	30.7	10	0.01500	0.07000	
25.4	30.3	50	0.00670	0.03200	D
24.5	—	100	0.00490	0.02320	
26.8	—	10	0.02645	—	
27.5	—	50	0.00505	—	E
25.0	—	100	0.00320	—	
20.0	—	10	0.00250	—	
16.0	—	50	0.00100	—	F
20.0	—	100	0.00075	—	
10.4	—	10	0.00560	—	
13.7	—	50	0.00260	—	G
14.8	—	100	0.00101	—	

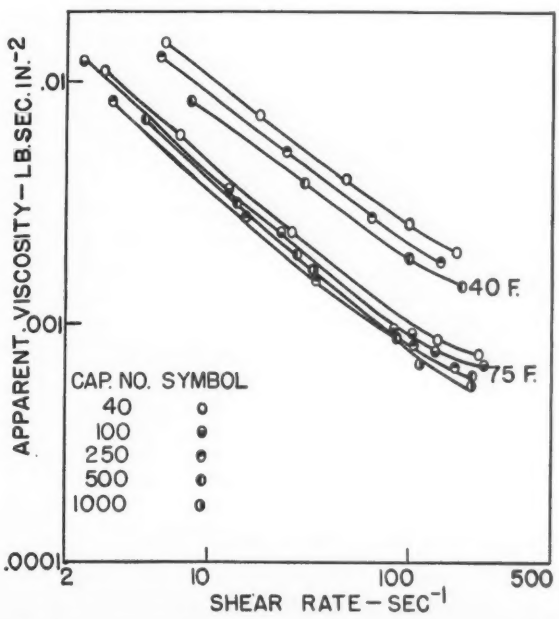

Figure 3. Apparent viscosity vs shear rate for grease B.

19.05 percent soap, respectively, and a 440 second oil. An examination of their viscosity curves at 75°F shows the percentage change in apparent viscosity at constant shear rates to be nearly the same for the three greases. Greases B and C show a greater change at 40°F than at 75°F, but the percentage change in apparent viscosity at the same shear rates is about the same for the two greases. Grease F, which had 4.5 to 5 percent sodium soap and a 1200 second oil, exhibited the same percentage change in apparent viscosity at constant shear rates as did greases A, B, and C.

Greases D and E had 4.7 and 11.5 percent soap, respectively, but E had an oil of 4213 seconds while D had an oil of 1412 seconds. A comparison of the percentage change in apparent viscosities at constant shear rates shows them to be approximately the same as each other, but higher than the four already discussed. Grease D at 40°F also shows a greater change than at 75°F.

Grease G was an extreme pressure lubricant containing 5 to 7 percent lithium soap and an oil whose viscosity at 210°F was 75 seconds, with no data available on the oil at 100°F. The percentage change in apparent viscosity at constant shear rates is less than any of the other six greases.

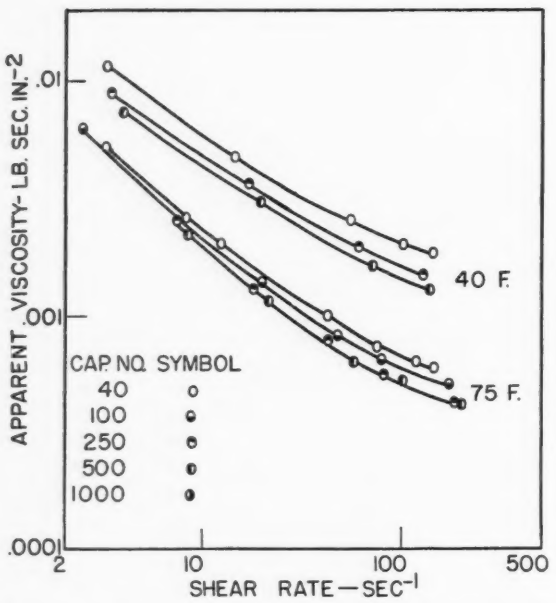

Figure 4. Apparent viscosity vs shear rate for grease C.

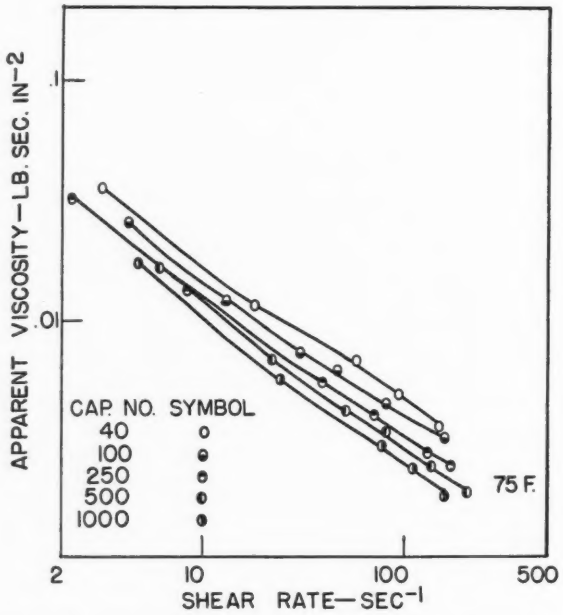

Figure 6. Apparent viscosity vs shear rate for grease E.

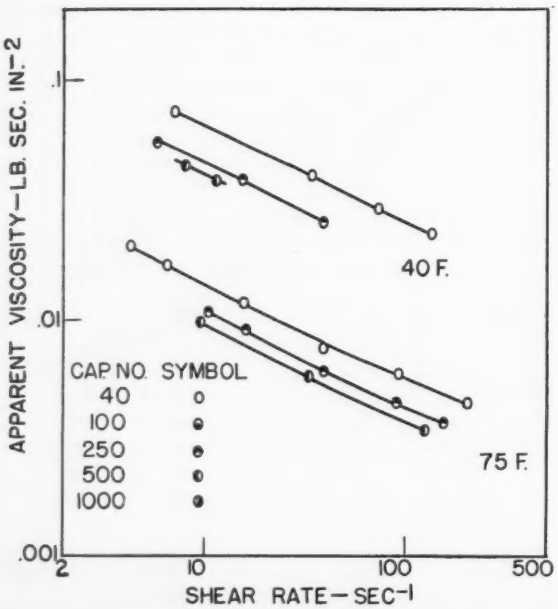

Figure 5. Apparent viscosity vs shear rate for grease D.

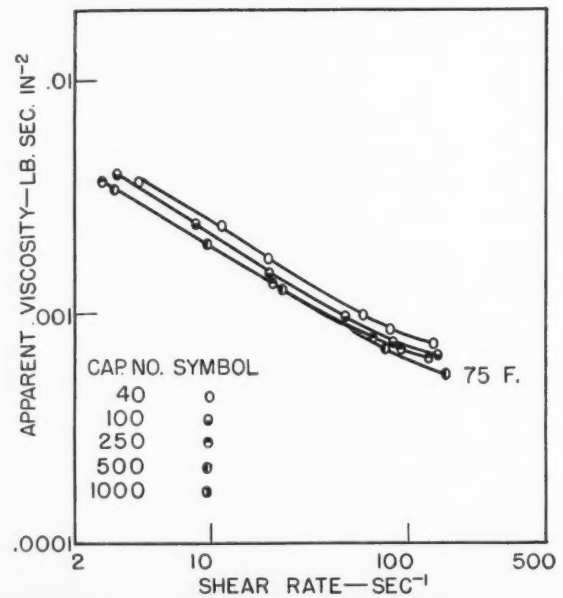

Figure 7. Apparent viscosity vs shear rate for grease F.

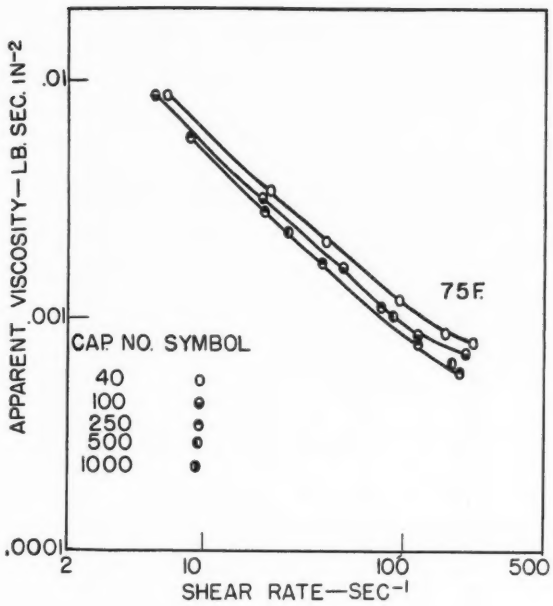

Figure 8. Apparent viscosity vs shear rate for grease G.

Data on soap structure were not available for the commercial greases, but since greases A, B, and C were experimental greases, it was learned that the sodium soap had a shorter fiber than is normally used. An examination of the data shows that the percentage change in apparent viscosity at 75° F and 40°F was nearly independent of the amount of soap. Thermal and X-ray diffraction studies indicate that the major portion of the soap in greases is in crystalline aggregate form, rather than as dissolved soaps or jellies (5). Direct photographs obtained with the electron microscope (6) show the prevalence of fibers, although they vary considerably with different soaps, but as the temperature is raised above room temperature, the fibers soften step-wise as they pass through their phase transitions. Examination of soap structures after working also shows the fibers to be broken and their length to diameter ratio greatly reduced.

Unfortunately, the authors had no data on the length to diameter ratio of the soap fibers, nor was the necessary equipment available to study the structure. The curves indicate that a limit can be reached for definite shear rates beyond which no further change in apparent viscosity takes place.

TABLE 3. CAPILLARY DATA

Cap. No.	Diameter	Length
40	0.1940	7.76
100	0.1940	19.40
250	0.1940	49.5
500	0.1940	97.0
1000	0.1940	194.0

TABLE 4. TEST RESULTS AND DATA FOR GREASE B AT 75°F

Cap. No.	Pressure, psig	cm^3/sec	μ
40	4.85	0.015	0.01075
40	6.02	0.046	0.00506
40	8.63	0.201	0.00181
40	13.71	0.710	0.00091
40	18.00	1.27	0.00083
40	24.00	2.23	0.00067
250	28.00	0.017	0.00904
250	40	0.100	0.00243
250	50	0.254	0.00140
250	80	0.851	0.00083
250	120	2.05	0.00057
500	60	0.029	0.00665
500	80	0.103	0.00265
500	100	0.227	0.00165
500	150	0.713	0.00088
500	240	2.28	0.00049

TABLE 5. TEST RESULTS AND DATA FOR GREASE B AT 40°F

Cap. No.	Pressure, psig	$cm^3/sec.$	μ
40	12.47	0.041	0.01485
40	20	0.169	0.00611
40	30	0.438	0.00367
40	40	0.872	0.00257
40	50	1.41	0.00206
250	70	0.038	0.01290
250	120	0.225	0.00413
250	180	0.631	0.00240
250	240	1.238	0.00173
500	140	0.069	0.00747
500	240	0.315	0.00316
500	360	0.892	0.00181
500	480	1.60	0.00140

TABLE 6. TEST RESULTS AND DATA FOR GREASE C AT 75°F

Cap. No.	Pressure, psig	cm^3/sec	μ
40	2.64	0.022	0.00491
40	3.76	0.089	0.00193
40	5.91	0.334	0.00095
40	8.14	0.654	0.00073
40	10.34	1.06	0.00061
40	12.53	1.46	0.00056
250	18	0.045	0.00262
250	25	0.155	0.00119
250	35	0.380	0.00076
250	50	0.846	0.00055
250	85	2.163	0.00041
500	36	0.048	0.00243
500	50	0.175	0.00105
500	70	0.477	0.00064
500	100	0.924	0.00053
500	160	2.15	0.00040

TABLE 7. TEST RESULTS AND DATA FOR GREASE C AT 40°F

Cap. No.	Pressure, psig	cm^3/sec	μ
40	5.29	0.026	0.01089
40	10.31	0.129	0.00451
40	20	0.482	0.00251
40	30	0.982	0.00194
40	40	1.52	0.00174
250	30	0.030	0.00841
250	60	0.164	0.00328
250	120	0.621	0.00182
250	180	1.319	0.00136
500	60	0.037	0.00703
500	120	0.200	0.00271
500	240	0.763	0.00155
500	360	1.49	0.00125

The percentage change in apparent viscosity at constant shear rates increased when the temperature of the grease was decreased. It is doubtful that wax was precipitating out of the oil to form a third phase, since all of the companies from whom the greases were obtained said the oils were wax free. It appears more likely that the soap structure changed with decreasing temperature.

TABLE 8. TEST RESULTS AND DATA FOR GREASE E AT 75°F

Cap. No.	Pressure, psig	cm^3/sec	μ
40	20	0.017	0.04128
40	30	0.108	0.01109
40	40	0.361	0.00506
40	50	0.735	0.00337
40	60	1.23	0.00251
250	90	0.012	0.03883
250	120	0.043	0.01343
250	170	0.256	0.00462
250	210	0.473	0.00324
250	280	1.17	0.00201
250	320	1.59	0.00176
500	220	0.033	0.01689
500	270	0.122	0.00655
500	330	0.298	0.00361
500	400	0.578	0.00255
500	500	1.13	0.00179
500	600	1.93	0.00134
1000	400	0.025	0.01937
1000	450	0.045	0.01284
1000	500	0.132	0.00555
1000	700	0.508	0.00239
1000	825	0.822	0.00187
1000	950	1.33	0.00141

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Considerations in Filter Selection

(Cont. from p. 210)

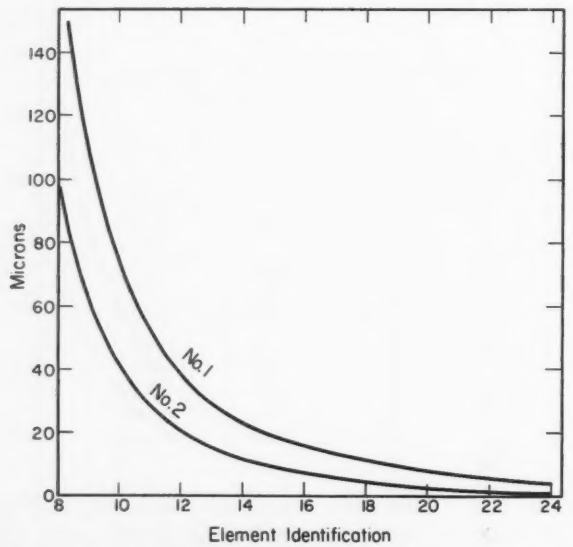


Figure 6. Element particle-removal rating.

size of the particle that has to be retained. It applies to the initial investment, as well as upkeep. Good practice dictates utilizing no more density than is consistent with the desired end results. The filter element should have the selective feature of providing within close limits only the degree of clarity needed. It is uneconomical to assign an element rated at 20 microns to an application requiring 70 micron cleanliness. The filter should be sized to allow no more than the maximum allowable flow per element so as to obtain maximum efficiency. And finally, in selecting a filter element, check to find out if the particle-size rating has been made scientifically and under conditions that approximate as nearly as possible those that would be actually encountered in the field.

ACKNOWLEDGMENT

The assistance of E. R. Adams of our Chemical Laboratory is gratefully acknowledged in the preparation of this paper.

In order to accommodate the steadily increasing volume of articles on lubrication subjects, ASLE will henceforth print a portion of its papers in a new publication to be known as ASLE Transactions. This new semi-annual publication can be obtained on subscription by ASLE members **only** as $5.00 per year; **non-members** may obtain the new Transactions at $15.00 per year from Pergamon Press Inc., 122 E. 55th St., New York 22, N. Y. Author's abstracts of the papers appearing in Volume 1, No. 1 follow:

Abstracts of Papers

Appearing in ASLE Transactions

F. C. Wagner and J. T. Burwell, Jr., "*New Retainer Materials for Aircraft Gas Turbine Bearings.*"

A study of the wear behavior of several classes of potential cage materials for aircraft gas turbine bearings was conducted, using a special wear-testing machine to approximate the projected service conditions of such bearings.

It was found that:

1. Several heterogeneous alloys containing silver as a soft, low shear strength phase showed superior wear properties to presently used silicon-containing nickel-copper alloy ("S" monel) and iron-silicon bronze, even when silver-plated. The latter alloys were used as reference cage materials.

2. The hard, load-supporting phase showing the most promise was a nickel base with additives of silicon or a silicide.

3. The materials showing the best wear properties were most efficiently fabricated by powder metallurgy techniques, utilizing the infiltration method for adding the silver.

J. B. Accinelli, "*Grease Lubrication of Ultra-High Speed Rolling Contact Bearings.*"

The failure mechanisms of grease lubricated ball bearings operating in the DN range from 1.0×10^6 to 2.0×10^6 was studied. A new rig capable of controlled operation of 20 and 25 mm ball bearings at speeds up to 100,000 rpm is described. Ball separator design seems to be a very important factor and a lightweight single piece machines outer ring controlled ball separator appeared to give the best results. In general, mechanical factors such as vibration, bearing design, bearing fit and tolerances, dynamic balance, load alignment, etc., have more influence on the performance of the bearings studied than gross grease variables. Under ideal conditions it is indicated that adequate lubrication with grease is possible for periods over 100 hours. However, under the test conditions generally in existence in the ultra high speed rigs grease lubrication was only adequate for very short periods.

Grease compositional factors leading to better performance are smooth texture and hard consistency. At the temperature investigated diester type oil was slightly superior to mineral oil and greatly superior to silicone oil.

T. L. Carter, R. H. Butler, H. R. Bear and W. J. Anderson, "*Investigation of Factors Governing Fatigue Life with the Rolling-Contact Fatigue Spin Rig.*"

A simple bench test for evaluating materials and lubricants under actual rolling-contact stresses is described. Stress-life relationships for mineral-oil lubricated SAE 52100 balls and AISI M-50 (MV-1) tool steel cylinders compared favorably with those obtained in full-scale bearings. Most failures originated in subsurface shear and closely resembled those obtained in bearings.

A study of the effect of fiber orientation on fatigue strength revealed that the polar (or end grain) area was weaker in fatigue than the non-polar area. Structure changes were found in the highly stressed regions of both SAE 52100 and AISI M-1 tool steel. Inclusions, structure change, and directionalism are believed to adversely affect fatigue life.

Henry E. Mahncke and David J. Boes, "*A Dynamic Oxidation Test to Evaluate Grease Performance at High Temperatures.*"

An instrument to evaluate grease on ball bearing performance at high temperatures under actual operating conditions has been developed. Operation of the bearing in an oxygen atmosphere has considerably reduced the total testing time required. By measuring the rate of oxygen consumption during a test, data on the chemical changes taking place in the grease are obtained, and the time of grease failure can be pinpointed quite accurately and reproducibly.

Typical oxygen consumption curves of various greases, as well as data which show the effect of the internal bearing clearance and the bearing's ABEC classification on grease life, are included.

Mark E. Otterbein, "*The Effect of Aircraft Gas Turbine Oils on Roller Bearing Fatigue Life.*"

A series of fatigue life tests on aircraft gear box size (45 mm bore) roller bearings were conducted with various aircraft gas turbine lubricants and with specific reference to Mil-L-7808 and variations thereof. It is shown that the 7808 lubricants generally cause a marked reduction in fatigue life as compared to that obtained with a medium viscosity mineral oil. It is also shown that lubricant bulk viscosity is a major factor in life. Subsequent testing demonstrated that the addition of thickeners to 7808 lubricants and formulations of this lubricant for a high Ryder Gear Rating are not effective in raising the fatigue life. It also appears that the SOD lead corrosion test is not pertinent in bearing life. Suggestion is made that the 7808 specification be relaxed to allow of higher viscosity for heavily loaded bearings as in gear boxes.

T. F. Davidson and P. M. Ku, "*The Effect of Lubricants on Gear Tooth Surface Fatigue.*"

This paper presents some of the results of a recent investigation on the effect of lubricants on gear tooth surface fatigue (pitting). The work described comprises the development of a laboratory test procedure for exploratory purposes, and the determination of the performance of a number of lubricants using this procedure. It was found that bulk lubricant viscosity, as measured by the conventional viscometric method, did not have a predominant effect on gear tooth surface fatigue. Examination of the development of scuffing and pitting on the gear teeth indicates that the initial incidence of scuffing and the initial incidence of pitting were unrelated. It was further noted that as pitting became advanced, severe scuffing of the pitted teeth would almost invariably result. On the other hand, there was no evidence that severe scuffing would lead to gear tooth pitting.

H. S. White, "*Laboratory Tests with Turboprop Lubricants.*"

The Modified SAE EP Lubricants Testing Machine and the McKee EP Lubricants Testing Machine use two contacting cylindrical test cups which are rotated at different speeds under load to give combined rolling and rubbing action typical of gear teeth. With these machines methods were developed for evaluating the anti-wear and the load-carrying properties of turboprop lubricants. Data are presented for 31 oils tested on the above machines, and for 25 of these oils also tested for stability at high temperatures on the McKee Oil Stability Apparatus.

(Cont. on p. 222)

(Cont. from p. 221)

T. W. Selby, "*The Non-Newtonian Characteristics of Lubricating Oils.*"

Interest is growing concerning the influence of polymeric additives upon the viscosity of mineral oils at extremes of temperature, pressure, and shear. In this paper the author discusses the viscometry of mineral oils and mineral oil-polymer blends at moderate temperatures and high shear and at low temperatures and low shear.

The non-Newtonian influences of two common polymeric additives, polyalkylmethacrylate and polyisobutylene, are shown to vary considerably at low temperatures in their effects on a common base oil. Shear dependence of polymer-containing oils at high shear rates is experimentally indicated to reduce the viscosity of the blend to approximately that of the base oil.

Conclusions of practical interest are drawn from the experimental results.

Wladimir Philippoff, "*Viscosity Measurements on Polymer Modified Oils.*"

The experimental check described proved that viscosity measurements on polymer modified oils with rotational and capillary viscometers can be successfully correlated. The rules for this are the same as those used for other non-Newtonian liquids (solutions of high polymers); namely, viscosity vs. the rate of shear at the wall, R. This is valid to at least 10^6 sec^{-1}.

V. P. Calkins and C. G. Collins, "*General Radiation Damage Problems for Lubricant and Bearing-Type Materials.*"

The actual mechanism of radiation damage to materials by reactor radiation is a matter of prime importance. Radiation damage to convalent compounds such as organic lubricants by reactor radiation is due primarily to secondary ionization caused by fast neutrons, slow or thermal neutrons, and gamma rays, and is not largely due directly to the initial interaction of any of these three types of radiation with the nuclei or atoms of the organic compounds. The amount of energy absorbed by a given material from these various types of radiation can be calculated, and the actual damage incurred is a function of the energy absorbed. Based upon available experimental test data of radiation damage to various organic materials and based upon the equivalent absorbed energy-equivalent damage concept, various generalizations regarding organic lubricating materials can be made.

Richard G. Abowd, Jr., "*Chrome Face vs. Iron Side Wear—An Analysis of Some Radioactive Piston-Ring Wear Studies.*"

This paper discusses piston ring wear data obtained from operating a single cylinder internal-combustion engine fitted with an irradiated standard chromium plated top compression ring. A brief description of the engine equipment, the constantly-monitored lubricating oil flow system, the dual-channel gamma spectrometer and an outline of test method are included. The author stresses the development of a technique which permits a separate simultaneous record of the wear occurring on the face and on the side of the radioactive piston ring. Results are presented from constant speed engine operation with a series of different lubricating oil additive formulations.

E. Rabinowicz, "*Theoretical Criteria for the Effectiveness of a Lubricant Film.*"

The occurrence of galling when unlubricated surfaces are slid together is shown through an energy balance to be determined by the parameter $W_K \cot \theta/p$, where W_K is the work of adhesion of the system, θ the average slope of the surface, and p the flow pressure of the softer metal. For lubricated surfaces, it is shown that only lubricants made up of very small molecules can be energetically stable on hard metal surfaces, and hence successful lubricants must form solid surface films. At the melting point of the lubricant film a transition takes place and the lubricant loses much of its effectiveness, while a second transition occurs at a higher temperature and leads to galling. This second transition is caused by desorption of the lubricant accompanied by a rise in W_K but varies widely for different metals, being influenced by their flow pressure.

M. Cocks, "*The Role of Atmospheric Oxidation in High Speed Sliding Phenomena—II.*"

An experimental study of the role of oxidation due to frictional heating in unlubricated high speed (13000 ft./min) sliding of metals is discussed. Detailed results for steel on steel have been described in another paper (1). This paper discusses a general picture correlating the results for several metal combinations and also a bonded metal carbide. The results indicate that the oxidation gives considerable protection against surface damage. With copper on copper (previously run-in), copper on steel, and bonded tungsten carbide on bonded carbide relatively little tearing of the metal (or carbide) is observed at light loads. The oxidation should increase with increasing load, and these combinations behave like steel on steel in that on at least one of the surfaces there is, if anything, even less metallic tearing at high load. At low loads wear is mild, in harmony with the oxide protection, but at higher loads severe wear is attributed to disintegration within the oxide itself. With nickel on nickel the oxidation fails to prevent fairly severe metallic tearing even at high loads. Some consequences of these phenomena in the variation of friction, wear and surface damage with load, speed and sample geometry are described.

L. F. Coffin, Jr., "*Boundary Lubrication, Wear-In and Hydrodynamic Behavior of Bearings for Liquid Metals and Other Fluids.*"

Various material combinations are investigated in the form of thrust bearings in such fluids as sodium-potassium eutectic, xylene and spindle oil. It is found that with these fluids certain material combinations can be made to perform satisfactorily as hydrodynamic bearings by a process of wearing-in. With these unique combinations it is possible to obtain film thicknesses of the order of 10×10^{-6} inches by extreme wear-in. The characteristics of bearing worn in to this degree are reported and mechanisms for the observed effects discussed.

Max A. Swikert and Robert L. Johnson, "*Wear of Carbon-type Seal Materials with Varied Graphite Content.*"

Most carbon-type seal materials contain graphitic carbon as the minor-constituent. Materials having graphite carbon as the major constituent were studied as possible seal materials at 10,000 feet per minute sliding velocities, in most experiments the temperature of the mating surfaces was 500°F. Carbon materials made graphitic by electro-graphitization were too soft; they gave high wear and high friction. Bodies molded with high-graphite-content materials and made hard by improved molding methods and impregnation gave acceptable friction and wear properties.

When a hardenable stainless steel was used, the effect of varied hardness of mating surface on wear of typical carbon was slight. Within a limited range, roughness of mating surface is not important to wear of carbons.

E. P. Kingsbury, "*Solid Film Lubrication at High Temperature.*"

The behavior of several solid film lubricants has been experimentally established as a function of temperature. These films are formed of a suspension of lubricant particles (graphite, molybdenum disulfide) in a thermosetting resin baked onto a hard surface. The test consists of heating such a layer and continually observing the friction coefficient until failure. Sliding conditions of high unit loading and low rubbing velocity were chosen to provide a comparison between the films. They were evaluated as to the highest temperature for which the friction coefficient remained low and subsequently as to the number of load cycles sustained at temperature before an abrupt increase in friction. Results for all films were similar in that failure was caused by a breakdown of the binder rather the lubricating particles and that the minimum friction coefficient ($\sim$0.03) was observed just before the film failure at temperatures as high as 1200°F.

F. F. Ling and Edward Saibel, "*On A Criterion of Cutting Velocity in Metal Machining.*"

The conventional model of orthogonal cutting with Type 2 chip is modified to include the effect of deformation of the work-piece at the immediate vicinity of the tool-tip. The cutting velocity condition for optimal force of deformation is examined in the light of two alternate criteria: recrystallization temperature and melting temperature. It is shown that a critical cutting velocity exists. Furthermore, it is concluded, in part, that proper metallurgical treatment and/or preheating the work-piece (hot machining) will improve cutting.

A. Dorinson, "*A Theory of Cutting-Tool Wear and Cutting-Oil Action.*"

The initiating step in cutting-tool wear is postulated as a temperature-dependent migration of chip metal into the tool. The migrated metal softens the tool, which allows wear particles to adhere to the moving chip and be carried away. The kinetics of these processes are developed quantitatively to yield an expression which explains the Taylor equation in terms of the fundamental parameters of cutting. The action of cutting-oils is regarded as a competition between the rate of alloying and softening of the tool by migrated chip metal and the rate of reaction of the migrated chip metal with the cutting-oil additive. The kinetics of these competing processes are then developed quantitatively to explain the behavior of the Taylor equation when metal is cut in the presence of cutting-oil.

L. F. Coffin, Jr., "*A Fundamental Study of Synthetic Sapphire as a Bearing Material.*"

Some experiments are reported on the sliding behavior of synthetic sapphire against certain fairly pure metals as a function of temperature. The initial selection of the sapphire-metal couple was determined on the basis of thermodynamic and physical consideration so as to produce, theoretically, a weak interfacial contact region. It was observed that this basis for selection of desirable sapphire-metal couples needed to be modified to include the effect of the surrounding atmosphere. For example, the couple sapphire-nickel should exhibit theoretically a low wear rate, weak adhesion and low friction. It was found, however, that the adhesion effects for this couple were highly sensitive to the presence of oxygen, and unless the oxygen was completely excluded, high friction and metal transfer occurred. The couple sapphire-gold, on the other hand, exhibited low friction and metal transfer regardless of atmosphere and elevated temperature. Hence, it would appear that the resistance to oxide formation by the metal is an important criterion for good sliding characteristics in metal-ceramics couples in sliding contact.

Experiments on the sliding characteristics of the couples as a function of both high and low temperatures are included and discussed.

G. L. Pigman and W. M. Keller, "*Friction and Oil Feed Characteristics of Journal Box Packing.*"

An investigation was concluded to determine the friction and oil feed characteristics of the cotton waste pack used for railroad journal bearing lubrication. The investigation also included wool and nylon fiber materials. An apparatus was constructed in which the pressure force between the waste pack and journal could be controlled and measured and the journal friction torque determined. A scraping technique was devised to measure the oil film thickness on the journal.

It was found that the friction between the oil saturated waste pack and journal arises from viscous shear of the oil. The coefficient of friction normally has values in a range from about 0.4 to 1.3. The total pressure force varies in value from about 2 lb to 150 lb, depending upon the waste pack condition.

The oil film established on the journal by feed from the waste pack normally has a thickness from about 0.0001 in. to 0.0005 in. The oil film thickness decreases with increased oil viscosity, journal speed, and pressure force on the journal.

The friction and oil feed properties of the waste pack are not affected in significant degree by change in waste pack fiber material.

A. A. Raimondi and John Boyd, "*A Solution for the Finite Journal Bearing and its Application to Analysis and Design: I.*"

The first in a series of papers are directed towards facilitating the analysis and design of journal bearings. By employing computer techniques, numerical solutions of Reynolds' equation are obtained for centrally-loaded bearings having arcs of $\beta = 360°$, $180°$, $120°$ and $60°$ for the widely used case of $L/D = 1$. Assumptions are based on constant viscosity and no film rupture. Performance curves are presented which eliminate the need for side leakage factors; the ease of application of the charts is shown by two illustrative problems. The effect of changing such design parameters as bearing clearance is illustrated.

A. A. Raimondi and John Boyd, "*A Solution for the Finite Journal Bearing and Its Application to Analysis and Design: II.*"

This second in a series of papers is a continuation of the work described in Part I. Performance curves for $\beta = 360°$, $180°$, $180°$, and $60°$ bearings are given L/D values of ½ and ¼ thereby extending the solutions to encompass both the L/D ratios and bearing arcs most widely used in practice. A problem illustrating the effect of L/D ratio on journal misalignment shows that the shortest bearing is not necessarily the one most capable of tolerating the maximum misalignment.

A. A. Raimondi and John Boyd, "*A Solution for the Finite Journal Bearing and its Application to Analysis and Design: III.*"

This is the concluding paper in a series. The effect of modifying the assumptions in Parts I and II to include the influence of rupture of the film is discussed in detail. Numerical solutions which account for film rupture are presented for Reynolds' equation in the form of performance curves and tabulated data for centrally-loaded bearings having arcs of 360°, 180°, 120° and 60° for L/D values of ∞, 1, ½ and ¼. The method of obtaining the computer solutions is discussed in the appendix and the results compared with similar work of other investigators.

W. F. Hughes and F. Osterle, "*Temperature Effects in Journal Bearing Lubrication.*"

Treating viscosity as a function of temperature and pressure the problem of the journal-bearing without side-leakage is solved for the temperature and pressure distributions for the case of adiabatic flow of the lubricant subject to the Reynolds boundary conditions. A numerical example is solved to illustrate the method.

Alfred M. Loeb, "*The Determination of the Characteristics of Hydrostatic Bearings through the use of the Electric Analog Field Plotter.*"

In many applications of hydrostatic lubrication to journal and thrust bearings, determination of flow, load carrying capacity and film thickness is at best an approximation. Anything but the simplest shape is difficult to analyze. The simplified form of Reynolds' equation which applies to hydrostatically lubricated bearings of constant film thickness is analogous to the electric field equation which describes the voltage distribution in a conducting sheet of constant thickness. This analogy suggests the use of the electric analog field plotter to determine the characteristics of hydrostatic bearings.

In this paper the theoretical basis for this method is discussed. In addition, the solution of a journal bearing is presented along with equations for several other useful shapes. Experimental verification of the journal bearing solution is presented, which indicates that this method may be employed with considerable accuracy.

F. Osterle and Edward Saibel, "*The Effect of Bearing Deformation in Slider-Bearing Lubrication.*"

The slider-bearing with the bearing elastic is analyzed for its load carrying characteristics. The deflection of the bearing under load acts to reduce the load capacity by an amount which can be significant as is illustrated by a numerical example.

R. A. Baudry and G. E. Peterson, "*Some Mechanical Considerations in the Design of Large Thrust Bearings.*"

The modern thrust bearing is a very important part of the waterwheel generator, for it must support the weight of the rotating parts of the turbine and generator and the hydraulic thrust load. With the continuous increase in size of hydroelectric generating units, machines now are built with thrust loads well above 1000 tons and requiring bearings ten feet in diameter or larger. Continuous trouble-free operation for periods of twenty years or more are desired for the bearings of large hydroelectric units.

Except during the starting period, the pivoted pad thrust bearing operates according to the well-known hydrodynamic theory of lubrication which permits the predetermination of its performance with reasonable accuracy. Alternating slipping between the thrust bearing runner and the supporting structure can result in excessive wear which destroy the accuracy of the bearing surfaces. Such wear can cause undesirable vibrations or damage to the bearing surface which prevents the formation of an adequate oil film. As a result of laboratory tests and experience in the field, it is now possible to make large thrust bearings with a supporting structure which will permit them to operate continuously for long periods of time with practically no wear or loss of adequacy.

Product Literature

APPLICATION MANUAL ON MOLYKOTE COATINGS

Bulletin 115, a handy, 24-page manual which details the preparation of metal surfaces for the proper application of Molykote resin bonded lubricant coatings, has been published by The Alpha-Molykote Corporation. The manual includes instructions for degreasing all metals, phosphating stainless steels, sandblasting chrome plate, nickel plate and stainless steel, anodizing aluminum and aluminum alloys, dichromate treatment for magnesium and magnesium alloys, bright dip-treatment for copper and copper alloys, and phosphate fluoride coating of titanium and titanium alloys. Application of lubricant coating by either spraying or dipping and required baking times are covered. Copies of Bulletin 115 are available from The Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

DATA SHEET DESCRIBES RINGS, SEALS, AND SHAFTS

A data sheet, describing and illustrating the various specifications and uses of welded hard-faced rings, seals and shafts, has been released by Cleveland Hard Facing, Inc. Manufactured in all stainless steel and ferrous alloys, hard-facing overlays help reduce equipment downtime and provide an economical answer to reduced maintenance and replacement costs. Produced to specification these overlays are applied only to sections of components which are subjected to severe wear or corrosion. Hard-faced parts offer high compressive strength up to 256,000 psi and good flat impact and high hot strength. Other outstanding characteristics include resistance to corrosive acids and oxides and wear — such as erosion, abrasives and cavitation erosion. Copies of the data sheet may be obtained from Cleveland Hard Facing, Inc., 3047 Stillson Ave., Cleveland 5, Ohio.

ACCESSORIES CATALOG

A new catalogue of sampling equipment and other accessories for the Beckman IR-4 infrared spectrophotometer is now available from the Beckman/Scientific Instruments Division, Fullerton, Calif. The catalogue, Bulletin 725, lists and describes applications for large-volume and micro sampling cells for liquids, gases, and solids, prism interchange units, recording accessories, and other IR-4 attachments.

COST ESTIMATING GUIDE

A four-page estimating guide, outlining uses and costs for 37 different "building saver" products is now available from Building Products Division, L. Sonneborn Sons, Inc. The two-color illustrated brochure covers a full line of products for treatments of concrete floors and wood floors as well as admixtures for concrete and mortar, and waterproofing and dampproofing compounds. While products covered in this brochure are primarily for new construction, several of the wood treatments listed are designed for maintenance purposes. For each product, there is quick reading information on use, quantities required and method of application. From this information, specific products for any building construction or maintenance need can be selected. Special information is provided to aid in installation. The two-page chart serves as a ready reference on any building product specification. Copies may be obtained by writing to Building Products Division, L. Sonneborn Sons, Inc., Dept. G, 404 Fourth Ave., N. Y. 16, N. Y.

BARREL RACK LITERATURE

How modern materials handling techniques can be applied to steel drums for the first time by the use of newly developed portable steel barrel racks is described in literature available from Republic Steel Corp. A four-page brochure illustrated in color tells how the barrel racks permit the handling of stacked or empty barrels and drums with standard fork lift trucks. Barrels can be stacked to any practical height with the new units which are designed for two—and four-way fork lift truck entry. Bulletin 961 is available from the Pressed Steel Division of Republic Steel Corp., 6100 Truscon Ave., Cleveland 27, Ohio.

EMULSIFYING OIL BULLETIN

A new cutting oil under an old name is announced in Sun Oil Company's new Technical Bulletin 16 on Sunoco Emulsifying Cutting Oil, or S.E.C.O. This Bulletin describes the characteristics and advantages of this versatile emulsifying oil. Test results are outlined and illustrated. Copies of Technical Bulletin 16 may be obtained by writing to Sun Oil Company, Philadelphia 3, Pa.

BORON NITRIDE BULLETIN

"Boron Nitride" — a recently-issued technical bulletin sets forth the properties, advantages and uses of this easily-machined, impermeable ceramic material with unique electrical and corrosion-resistant properties for use up to 3000°F. The attractive four-page pamphlet contains typical analyses of boron nitride, tabulations of its oxidation in air, modulus of rupture, thermal conductivity, dielectric constant, resistance to chlorine, modulus of elasticity, thermal expansion coefficients, dissipation factor, and resistivity vs. temperature and humidity. It also indicates fabricability and possible uses of the material. In addition, a price schedule is available. Patented uses are: vacuum tube separators, dielectric applications, chemical equipment parts, molten metal pump parts, combustion chamber liners, thermocouple protection tubes, mold release agents, gaskets, seals, and rupture discs. Copies of the bulletin are available on request from: Manager, Advertising, The Carborundum Company, P.O. Box 337, Niagara Falls, New York.

TUBE FITTING CATALOG

A new 20-page, illustrated catalog, Number 058, covering straight-thread hydraulic tube fittings has been published by Flodar Corp. The new catalog provides complete engineering details plus ordering and installation instructions on the line which includes 45° and 90° elbows, tees and plugs in a variety of combinations. The fittings are designed to fit all S.A.E. portholes and are available in self-flaring, no-flare and flare types from ¼ in. to 2 in. o.d. Engineering drawings of each type are included along with a complete table of dimensions for each size. Available taps and counterbores needed for the proper installation of these fittings are also featured in the catalog. Copies of catalog No. 058 are available from Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio.

GUIDE TO PLASTIC TUBING

The whole story of Cobon Plastics Corporation's plastic tubing products has been capsulated in a new catalog. It is a detailed guide for the engineer and purchasing agent who must have — at his finger tips — all the technical information needed for the highly specialized tubing requirements of industrial production and laboratory research. This comprehensive booklet describes each of the company's plastic tubes giving information on uses, sizes, dimensions, chemical resistances as well as working pressures. All data and specifications are presented in a clear and concise manner in the new Cobon Plastics eight page catalog which includes the following regular products: Cobon — Polyvinyl Chloride; Cobonol Polyethylene; Coboflow — Teflon. Get your copy by writing Cobon Plastics Corp., 44 Lafayette St., Newark 2, N. J.

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society

Literature Abstracts — W. E. Campbell, Editor

"The Viscosity/Temperature Relationship of Lubricating Oils." E. G. Ellis. *Petroleum*, v. 20, no. 8, 1957, 294-98.
A review is given of the viscosity-temperature relationship of lubricating oils. The effect of temperature change, the Viscosity-Index and its limitations, and various theoretical and practical methods for determining this relationship are covered. (18 references.) *(Abstractor: E. O. Forster)*

"Use, Characteristics and Designation of Multigrade Motor Oils." J. Groff. (Institut Francais Du Petrole). *Journal de la Societe Ingenieurs Automobile*, v. 30, 1956, 57-66.
Largely a review of basic definitions and American work indicating the advantages of multigrade motor oils, this paper contains two new items. It shows how nomographs may be constructed for given oil-VI improper blends to arrive at optimum proportions for low-temperature starting. It also lists the velocity gradients in 4 French engines to estimate rates of shear and their effect upon viscosity. 35 references. *(Abstractor: M. I. Smith)*

"Why Better Lubricants." C. M. Heinen (Chrysler Corp., Highland Park, Mich.) *A.P.I. Proceedings*, v. 36, Sec. II, 1956, 149-58.
Current trends in automobile design impose more severe requirements upon type "A" transmission fluids. They must have greater fluidity at low temperatures, increased resistance to heat, higher specific gravity, and better compatibility with seal materials and metals. Standardization of tests on rear axle lubricants is discussed. Braking systems will be called upon to dissipate larger heat loads, and many fluids currently marketed do not have sufficiently high boiling points. *(Abstractor: M. I. Smith)*

"Some Problems Associated with the Recommendation and Use of Multi-Viscosity Oils." Lloyd Withrow (General Motors Research Laboratories, Detroit, Michigan). *A.P.I. Proceedings*, v. 36, Sec. II, 1956, 170-79.
Tests confirm claims that cross-graded oils increase octane number through reduction of combustion chamber deposits. It was found that use of such oils does not lead to excessive wear, exhaust smoking, high consumption, rusted valve stems or sticky lifters as is sometimes suspected. There is a tendency for build-up of intake valve deposits in laboratory tests on some engines, but consumer complaints are virtually nil. Low-temperature starting is more difficult with cross-graded than with conventional oils. A revision of the present system of extrapolating viscosities measured at 100° and 210°F to 0°F is suggested. The infrequency of consumer complaints in this area is probably due to the better over-all starting characteristics of newer engines, which are the chief users of multi-viscosity oils. *(Abstractor: M. I. Smith)*

"Laboratory Study of *N*-oleoyl Sarcosine as a Rust Inhibitor in Some Petroleum Products." R. M. Pines (Geigy Chemical Corp., Yonkers, N. Y.) and J. D. Spivack. *Corrosion*, v. 13, 1957, 92-6.
Laboratory studies indicate that *N*-oleoyl sarcosine is an effective rust inhibitor in solution in gasoline, mineral oil, and silicone lubricants. Rusting tests used include: the turbine oil rusting test, static immersion test, humidity cabinet test, and static water drop test. In addition, a number of auxiliary tests are run to indicate the effects on other properties of the test liquid. Hydrocarbon solutions of *N*-oleoyl sarcosine are particularly effective in preventing rusting in the presence of synthetic sea water and in resisting water extraction of the inhibitor. *(Abstractor: E. O. Forster)*

"Lubricant Specifications." E. G. Ellis. *Scientific Lubrication*, v. 8, no. 6, 1956, 14-5, 17-9, 21; no. 7, 10-12; no. 8, 23-8; no. 9, 19-25; no. 10, 14, 16-8, 20-4; v. 9, no. 1, 1957, 12-7; no. 2, 25-8; no. 3, 27-8, 30, 32, 34-5.
Trends of development and some of the latest British specifications for various types of lubricants are given. Some parallels are drawn with U. S. specifications, beginning with the SAE and B.S. 210 viscosity classification systems. Each article deals with the following subjects. V. 8, no. 6 — Introduction, viscosity. No. 7 — Gear and turbine oils. No. 8 — Railroad oils. No. 9 — I.C. Engine oils. No. 10 — Greases. V. 9, no. 1 — Cutting and refrigeration oils. Nos. 2 and 3 — Rust preventives. *(Abstractor: M. I. Smith)*

"Multipurpose Greases — Logging Applications." H. A. Woods (Shell Oil Company) and O. E. Willam. Soc. Automotive Engrs. Paper No. 162 for Meeting, August 12-16, 1957, 9 pp.
Improved metal wetting, corrosion protection and load-carrying properties of a lithium 12-hydroxystearate multipurpose grease are obtained through the use of a more viscous oil. Instead of a 35 VI oil, a blend of 30 VI and 90 VI oils is used. This new blend does not adversely affect the low-temperature properties of the multipurpose grease. A comparison is also made between this improved lithium 12-hydroxystearate grease and an inorganic microgel multipurpose grease now being developed for automotive applications. Future trends in the development of automotive type multipurpose greases are discussed. *(Abstractor: E. O. Forster)*

"Standards and Classification of Lubricants for Steel Mills." J. D. Lykins (Wheeling Steel Corporation). *Iron & Steel Engr.*, v. 34, 1957, 101-4.
A description is given of Wheeling Steel Corporation's standards and classifications for lubricants to reduce the number of products used in all its plants. The advantages of the resulting simplification are described. *(Abstractor: E. O. Forster)*

"Does Your Condensate Need De-oiling?" L. Walter (Consulting engineer, Gloucester, England). *Petroleum Refiner*, v. 36, no. 7, 1957, 194-5.
A method for recovering lubricating oil from the condensates of steam cylinders of reciprocating engines or steam pumps is described together with photographs of the apparatus.
The heat content of the condensate can be utilized by passing it through heat exchangers where it would give up its heat to boiler feed water. *(Abstractor: A. S. Gressl)*

"Report on Dynatomics." Phase I. A. McBride (Machines & Methods Development, El Segundo Division, Douglas Aircraft Co., Inc.). *Western Machy. & Steel World*, v. 45, no. 11, 1955, 88-91.
A new concept of metal removal called "Dynatomics" is advanced by the manufacturer of a proprietary coolant. The use of proper coolant, tool geometry, speeds and feeds produces the desired plastic flow during machining operations. Three types of coolants are investigated. The proprietary coolant "A" is a solubilized organic condensate containing chlorine, nitrogen, oxygen, and carbon in a complex molecule. The reference coolants are a soluble oil and a mixture of lard oil and kerosene. Coolants are applied in a vaporized condition. Preliminary lathe-turning tests indicate that coolant "A" will give greater tool life, higher surface finish and reduce coolant odor and smoke. *(Abstractor: W. Wojtowicz)*

"Report on Dynatomics — Phase II." A. McBride (Machine & Methods Development, El Segundo Division, Douglas Aircraft Co., Inc.). *Western Machy. & Steel World*, v. 48, no. 3, 1957, 91-3.

"Dynatomics", a new concept of metal removal, has been previously presented (ibid Nov. 1955). This report covers production applications of earlier findings and generally substantiates the expectations that the use of coolants recommended in the Dynatomics program would result in (1) greater tool life, (2) increased production, (3) higher surface finishes, (4) reduction of coolant odors and smoke, (5) improved maintenance of coolant system, and (6) improved personnel attitude. *(Abstractor: W. J. Wojtowicz)*

"The Frictional Properties of Molybdenum Disulphide." J. W. Midgley (Imperial College of Science and Technology) Symposium on Lubrication, Inst. Petroleum, v. 42, no. 395, 1956, 316-29.

Experiments are conducted in controlled atmospheres on natural molybdenum disulphide films of sufficient thickness that intermetallic contact is not possible. Results show that the frictional resistance of the MoS_2 film decreases with increased dryness of the film. At room temperature (55-65% relative humidity) the coefficient of friction is found to be 0.20; for a dried film $f = 0.05$. The drying out of the film can take place either by reducing the relative humidity or by frictional heating. *(Abstractor: M. B. Peterson)*

"Friction Studies of Graphite and Mixtures of Graphite With Several Metallic Oxides and Salts at Temperatures to 1000° F.". Marshall B. Peterson (NACA Lewis Laboratory, Cleveland, Ohio) and Robert L. Johnson. NACA Technical Note 3657, Feb., 1956.

An experimental friction study is made using graphite and mixtures of graphite with lead oxide, cadmium oxide, sodium sulfate, or cadmium sulfate as solid lubricants. Coefficient of friction is measured with various steel and inconel combinations using an apparatus which consists of three hemispherically tipped sliders rotating concentrically against a flat disk.

Graphite powder lubricates metal surfaces at temperatures sufficiently high to promote oxidation of the metal surfaces. At intermediate temperatures graphite powder alone fails to function as a lubricant. Graphite does not lubricate cast Inconel on Inconel X at temperatures betweeen approximately 150° and 800°F. Similarly, with steel, which oxidizes more readily than Inconel, the temperature below which graphite will not lubricate is 475°F.

Mixtures of metallic compounds and graphite are more effective lubricants ($f = 0.05$ to 0.20) throughout the temperature range than either constituent alone. Metallic compounds act as binders for the graphite since these mixtures yield identical friction coefficients to those for a resin-bonded graphite film at 400°F. *(Abstractor: M. B. Peterson)*

"A Study of New and Regenerated Motor Oils." A. B. Stern, Bulletin of the Research Council of Israel, Section C—Technology, v. 5, no. 2-3; *Sci. Lub'n.*, v. 9, no. 8, 1957, 16.

A series of tests were carried out in both Northern and Southern districts of Israel (using 6 cylinder Ford trucks of the F-1 type) on new and regenerated motor oils. The engines were afterwards stripped and examined. No fundamental difference can be detected in either the oils or engine performance characteristics. Properly regenerated motor oils blended with suitable additives are shown to give satisfactory results as motor lubricants. *(Abstractor: A. S. Gressel)*

"New Light on Grinding Fluids." H. R. Letner (Mellon Institute, Pittsburgh), *Steel*, v. 141, no. 3, July 15, 1957, 127, 129-30, 132, 134, 136.

A summary of results of grinding fluids evaluation in minimizing residual grinding stresses is graphically illustrated. The grinding fluids' effectiveness is measured by the resultant stress distribution produced on hardened (C 59) 52100 steel test bars. Dry grinding and eleven of three basic types of fluids are tested. Rust-inhibited water solution or soluble oils, stress-wise, have no significant benefit over dry grinding. The best results in ideal stress pattern distribution are obtained from two grinding oils. The composition is given for the eleven grinding fluids tested. *(Abstractor: Joseph Kirk)*

"Gas-Lubricated Bearings — Principles and Applications." C. W. K. Ford (Atomic Energy Research Establishment, Harwell, England), D. M. Harris, and D. Pantall. *The Machinery Market*, no. 2923, 1956, 27-30; no. 2924, Nov. 30, 26-30. Also, *Engineering*, v. 182, no. 4730, 1956, 559-62.

The advantages of gas bearings for certain applications are pointed out and their practicality illustrated by two examples in the atomic energy field. Experiments on self-acting gas bearings over a wide range of sizes and test conditions provide the basis for design. The ratio of maximum pressure developed in the journal to the ambient pressure is a key factor. If this exceeds unity by not more than about 10% compressibility effects are negligible; beyong that, load capacity is less than predicted by incompressible hydrodynamic theory. The examples described are a canned-rotor CO_2 circulating pump operating at 100 psi, 150°C, 13,000 rpm and using the CO_2 as the lubricant for self-acting journal and thrust bearings, and a liquid-bismuth circulating pump arranged vertically with an inert gas filling the sealed motor and bearing space and serving also as a surge tank for the liquid system. Design features of these two units are described together with information on materials, manufacturing technique, and assembly. The authors conclude, based upon many tens of thousands of running hours on machines of various designs and as many start-stop cycles on both journal and thrust bearings, that self-acting gas bearings can be made sufficiently rugged, reliable, and reproducible in performance for everyday service. *(Abstractor: V. H. McNeilly)*

"Maintenance of Compressor Engines by Lubricating Oil Analysis." D. V. Kniebes. *Gas*, v. 33, no. 6, 1957, 113-20.

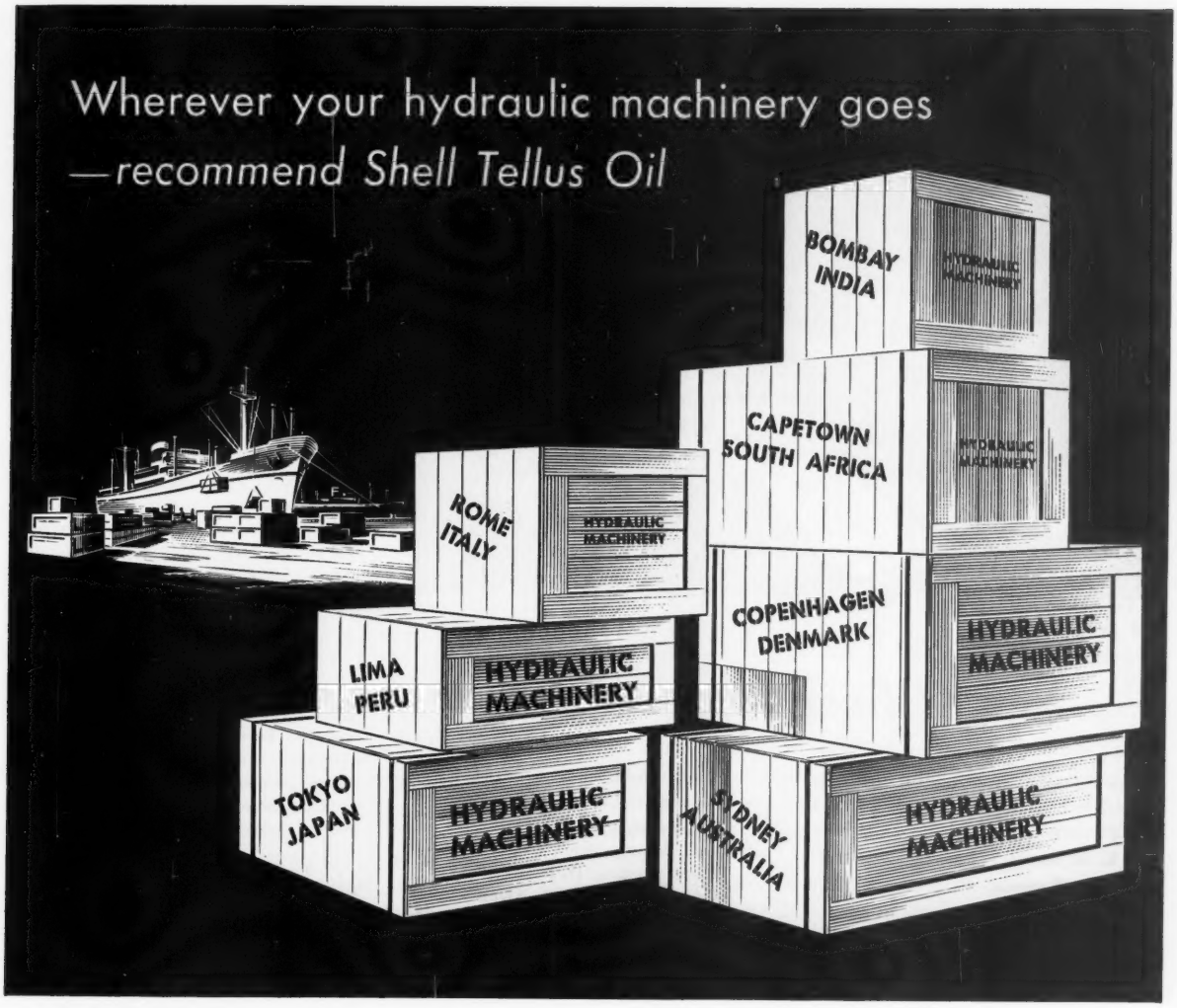
Wear in engines is correlated with the amount and type of metal contained in the lubricating oil. The emission spectrograph is used to determine the concentration in parts per million of silicon, iron, chromium, aluminum, copper, lead and tin in used oils. The silicon present represents dirt in the oil; iron is used to measure wear rate in cylinders and liners; chromium indicates wear on chrome-plated rings and liners; the other elements are used to indicate bearing wear. The many variables make interpretation difficult, but by careful study of these variables and their effect on results obtained, failures can be avoided. Among the facts which alter interpretation are the engine seasonal loadings, type of engine, oil additives, oil changes, filter changes, sealing compounds, and other sources of materials determined. With further study of techniques it is expected that predictions of engine condition will be possible with this low-cost analytical method. *(Abstractor: E. S. Reynolds)*

"The Influence of Lead on Metal-Cutting Forces and Temperatures." M. C. Shaw (Massachusetts Institute of Technology, Cambridge, Mass.), P. A. Smith, N. H. Cook, and E. G. Loewen., *Trans. Am. Soc. Mech. Engrs.*, v. 79, no. 5, 1957, 1143-54.

A comparative evaluation of a commercial cutting oil, a water-base fluid, and air has been made during a study of the effects of addition of lead and sulphur on machinability of steel. Fluids which are normally effective on ordinary steel may give poorer results than air upon steels containing lead or sulphur. This effect is especially notable at speeds of 150 fpm and above. It is suggested that the lubricant interferes with the action of the internal lubricant (lead) by making it more difficult to spread on the surface of the chip. Discussions are presented by F. W. Boulger and E. S. Nachtman. *(Abstractor: W. J. Wojtowicz)*

"Functional Testing of Cold Reduction Lubricants." J. F. Griffin (U. S. Steel Corp., Pittsburgh, Pa.) *J. of Metals*, v. 9, no. 8, 1957, 1042-3.

A modified Shell four-ball E-P tester, which operates at 0.3 rpm, 1,000,000 psi and embodies an electrically heated ball pot simulating mill operating temperatures, has been successfully adapted for evaluation of lubricating properties of rolling mill solutions. In addition, heat quenching qualities are determined with an apparatus developed by Standard Oil Co. (Indiana.) Both torque readings and quench rates are taken into consideration in appraising new lubricants. Annealing characteristics have been evaluated with a Test Strip Annealer supplied by the Columbia-Geneva Div., U. S. Steel Corp. The text contains drawings of the apparatus. *(Abstractor: W. J. Wojtowicz)*



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Section News

ASLE DIRECTORS 1958-59: Seated (Clockwise from left) H. W. McCulloch, Jr., J. W. Peterson, D. W. Sawyer, Director; C. L. Willey, Executive Secretary; J. D. Lykins, J. O. McLean, Chairman, Presidential Council; A. B. Wilder, Vice President-at-large; A. E. Cichelli, Coordinator, Joint Technical Committees; R. C. Dishington, and Wayne Lasky, past J. T. C. Standing are: B. T. Harding, Director; A. A. Raimondi, retiring Co-ordinator, J. T. C.; R. J. Torrens, D. M. Cleaveland, retiring Director; S. R. Calish, Jr., retiring Director; L. O. Witzenburg, Director; D. F. Wilcock, E. E. Bisson, and A. B. Two, Director. Canadian Regional Vice President S. C. M. Ambler and Central Regional Vice President P. A. Asseff were not present for the picture.

New Officers Announced

New directors and officers of ASLE were chosen last month. Those elected as directors are:

E. E. Bisson
R. J. Torrens
B. G. Symon

This year's officers will be:

President: **J. D. Lykins**
Vice President at large: **A. B. Wilder**
Secretary: **J. L. Finkelmann**
Treasurer: **J. W. Peterson**

Regional vice presidents are:

Eastern region: **D. F. Wilcock**
Central region: **P. A. Asseff**
Midwest region: **H. W. McCulloch, Jr.**
Western region: **R. C. Dishington**
Canadian region: **S. C. M. Ambler**

Baltimore—April dinner and social hour followed by discussion of "The Lubrication of Gears and Gear Units" by L. J. Collins of General Electric. Officers will be installed at May 16 meeting. . . . **Boston**—Visit to Wyman-Gordon's Grafton plant was followed by talk on "Die Lubricants" by the company's Jose R. Canal. . . . **Buffalo**—Early planning underway for 1959 ASLE annual meeting to be held in Buffalo April 21, 22 and 23. April speaker was George E. Kellis of Sinclair Refining Co., topic was "Grease Characteristics and Applications." Joint meeting planned for May 21 with Rochester Section; James Fally will discuss storage, handling, dispersing and application of lubricants. June 27 has been set as date for annual outing at Buffalo Launch Club—both the Rochester and Ontario sections are urged to attend. . . . **Chicago**—New officers are: E. W. Drummond, chairman, G. S. Metcalfe, vice-chairman, J. Sonnenfield, treasurer. Executive committee members are: S. E. Sparks, J. J. Holmes and N. Bauer. Those in attendance at April 17 meeting heard W. A. Magie of Magie Bros. Oil Co. discuss lubricating greases. . . . **Cleveland**—New officers are: George L. Smith, chairman, Carl C. Herrod, vice-chairman, Lowell O. Ray, secretary, Stanley L. Stalson, treasurer, John W. Merydith, membership chairman, Thomas Oster, program chairman. Members of the executive committee are Wm. A. Ursem and Howard T. Peoples. . . . **Duluth—Iron Range**—Carl Johnson of Erie Mining Co. spoke on "Laboratory Tests on Lubricants and their Significance." . . . **Houston**—New officers are: Travis Gordy, chairman, Steve Johnson, first vice-chairman (membership), Warren Elrod, second vice-chairman (programs), Harvey Benoit, treasurer, and Ed Shannon, secretary. April meeting was highlighted by discussion of Ingersoll-Rand. Subject of May 5 "bring-a-guest" meeting will be "Cutting Oils" discussed by E. O. Bennett, associate professor of biology at the University of Houston. . . . **Hudson-Mohawk**—E. Crankshaw, Cleveland Graphite Bronze Co., discussed "Bearings and Bearing Materials" at April 16 meeting. . . . **Intermountain**—Dudley P. Thomas, Columbia Geneva Steel Div. of U. S. Steel presented paper on "Gears and their Lubrication" at April 14 meeting.

. . . **Los Angeles**—Otto Neumer, S.K.F. Industries, spoke on "Design Application and Lubrication of Rolling Contact Bearings" at April 9 meeting after dinner and social hour. . . . **Milwaukee**—Plant tour of A. O. Smith Corp. highlighted April 16 meeting. . . . **New York**—Major papers of March 19 meeting were presented by Lee Schmohl, Parker-Hannifin Corp., whose subject was "Joint Industry Conference Standards, Fittings and Seals" and John G. Watson, also of Parker-Hannifin who discussed "O-Rings and Hoses." A 10-minute supplemental talk "Forward or Backward?" dealing with railway car journal lubrication was given by W. L. Stewart, American Brake Shoe Co. . . .

Northern California—"Improved Lubricants through Additives" were detailed by J. R. Stitt of Oronite Chemical Co. at April 10 meeting. May's meeting, the last of the season, featured discussion of "Lubrication of Roll-Neck Bearings in the Steel Industry" by W. H. Mandy of the Texas Company. . . . **Ontario**—"Planned Lubrication" was Eastman Kodak's Charles Pope's topic at April 8 meeting. . . . **Rochester**—Certificates were presented to lubrication course students who were dinner guests at April 16 meeting. . . . **Twin Cities**—Arthur J. Stock of Acheson Colloids Co. spoke on "The Lubricating Properties of Polytetrafluoro-Ethylene (teflon) Films" at April 17 meeting.

This department is reserved for those papers which, because of space limitations, cannot be published in full in Lubrication Engineering or ASLE Transactions.

Digest of Other ASLE Papers

Note: Unabridged copies of papers appearing in this department are not available at Society Headquarters. Those wishing additional information relative to such papers should contact the author.

RAILROAD LUBRICANTS — THEIR STORAGE AND HANDLING

by C. M. Larson, Consulting Engineer

Any lubricant can perform its intended function only when it is protected against contamination. This is axiomatic. When that function involves the protection against wear of machinery such as a railroad diesel, the insurance value of this protection is significant. Lubricants today are prepared to meet machine design and operating conditions. In railroad service the latter can be very severe, hence the widespread usage of additives to fortify against oxidation under high temperature conditions, and to impart adequate film strength to resist the prevailing pressures.

Protection of a lubricant begins at the refinery; it must be continued until the product is actually put in service in the machine. In railroad service as in other industries protection is a threefold project, involving handling, storage and dispensing. Judiciously studied and carefully planned they can effectually counteract or eliminate those prevalent causes of contamination or loss of lubricating ability which could result from entry of water or abrasive foreign matter, exposure to temperature extremes or careless handling and application.

The economic value of good housekeeping in the railroad lubrication and maintenance departments can be appreciated when it is considered that first cost per pound or per gallon is virtually insignificant as compared with the cost to handle, dispense and apply. According to the operation a dollar's worth of lubricant can cost from two to twelve dollars to put into service.—*Digested by A. F. Brewer.*

FILTRATION OF BRASS MILL COOLANTS

by Gordon E. Signor, Scovill Manufacturing Company

Roll cooling is an interesting phase of lubrication which is highly essential to the attainment of "buffing quality" and a surface finish free from imperfections or blemishes in brass rolling. Adequate roll cooling has a decided economic value in that it contributes to maximum roll output under controlled temperatures. The procedure has undergone quite a transition from the earlier routine of running streams of water on the rolls at the point of heat build-up, augmenting heat transfer and roll action by swabbing, spraying or dripping oil onto the metal as it approached the mill. This procedure was satisfactory with slow speed rolling when the coolant was clarified to some extent by bag filtration.

Modern brass rolling requirements, however, have called for increased roll speed and power in order to obtain greater reduction and the production of better quality strip. The research which was carried out in the study of mill design to accommodate these conditions quite naturally extended also to study of the roll cooling and lubricating facilities. Systems of oil reclamation had to be modernized in order to maintain the rolling quality of the oil and to insure that the water in use was properly clarified of sediment and other abrasive matter which in circulation could have an abrasive effect upon the brass. It involved a transition from simple floatation or settling, and heating to bring about the necessary separation. Particular attention was given to developing more positive means of oil reconditioning. Centrifugal treatment and polishing filtration served the purpose as the micron specification became more exacting.

Today the newer brass rolling mills are designed to include full flow filtration systems which will operate continuously and insure that no particle larger than 20 microns will be returned to the roll cooling system. These systems can handle either mineral oil and water or a soluble or emulsifiable compound, according to mill procedure. Automatic controls are installed and shell and tube heat exchangers for temperature control are included. The economic benefits to be derived from this unusual application of the principles of lubrication and lubricant protection are evidenced by greater customer satisfaction with the surface finishes produced.—*Digest by A. F. Brewer.*

Patent Abstracts

Compiled by
Ann Burchick, Aluminum Co. of America

Manufacture of Lubricating Oils, Patent No. 2,786,015 (W. N. Axe, assignor to Phillips Petroleum Co.) In a dewaxing process in which a lubricating oil stock is partially dewaxed in a first dewaxing step and then the partially dewaxed oils is dewaxed in a second dewaxing step comprising admixing the partially dewaxed oil with urea at a temperature in the range of 0 to 100 F. to form a precipitated urea-hydrocarbon complex, separating said complex from the last said admixture and recovering an oil having a low pour-point, the improvement which comprises conducting said first dewaxing step by forming an admixture of said lubricating oil stock with methyl isobutyl ketone and with liquid propane, said admixture having a volume ratio of said oil stock to said ketone within the limits of 0.20:1 to 1:1 and a volume ratio of said propane to said ketone within the limits of 1:1 to 5:1, chilling the resulting admixture to a sub-atmospheric temperature within the range of 0 to —60 F. by vaporizing propane therefrom so as to thereby precipitate wax from the oil component to partially dewax said oil, and separating the precipitated wax from said admixture.

Anti-Corrosive Lubricating Oil, Patent No. 2,786,028 (R. I. Gottshall and R. T. Kern and J. G. Peters, assignors to Gulf Oil Corp.) An improved lubricating composition consisting essentially of a major proportion of a mineral lubricating oil and minor proportions consisting of about 0.1 to about 5.0 percent by weight of an alkyl phenol, said alkyl phenol containing at least one alkyl group containing between 3 and 12 carbon atoms, about 0.001 to about 1.0 percent by weight of a substantially neutral addition product of 3-methylbutyl,2-ethylhexyl acid orthophosphate and a primary fatty amine, said amine, being a mono-alkyl amine containing from 8 to 18 carbon atoms, about 0.01 to about 0.3 percent by weight of an alkenyl-substituted succinic acid anhydride wherein the alkenyl group contains from 5 to 18 carbon atoms, and about 0.001 to about 1.0 percent by weight of an acid ester of (1) a dimeric acid derived from an unsaturated fatty acid containing 18 carbon atoms and having from 2 to 3 ethylenic linkages per molecule and (2) a partial ester of a fatty acid containing 18 carbon atoms and a hexitol anhydride.

Lubricating Oil Composition, Patent No. 2,786,029 (W. H. Brugmann, Jr., assignor to Esso Research & Engineering Co.) A mineral lubricating oil composition comprising a major proportion of a mineral lubricating oil containing dissolved therein about 0.02% to about 5% of a non-acidic metal salt of the product formed by reacting one molecular proportion of an acid of phosphorus.

Detergent Lubricating Oils, Patent No. 2,786,030 (T. L. Cantrell and H. G. Smith, assignors to Gulf Oil Corp.) A lubricant composition comprising a major amount of a mineral lubricating oil and a minor amount, sufficient to confer detergency properties on the composition, of an alkaline earth metal salt of a condensation product of 2 mols of a monoalkylated monohydric in the alkyl group, 2 mols of a lower phenol having at least 4 carbon atoms alkanol, 2 mols of carbon disulfide and from 2 to 3 mols of formaldehyde.

Transparent Cutting Oil Containing Active Sulfur and Sulfochlorinated Mono-Olefin Polymer, Patent No. 2,786,031 (R. C. Givens, assignor to The Texas Co.) A transparent cutting oil consisting essentially of a mineral lubricating oil distillate having an SUS viscosity at 100 F. of 100 to 200 containing 0.4 to 0.95 percent by weight of added active free sulfur incorporated in the mineral oil at a temperature of about 290-340 F., and 0.75 to 5% by weight of sulfurized and chlorinated diisobutylene containing 23-25 percent of combined chlorine and 19-22 percent of combined sulfur, said sulfurized and chlorinated diisobutylene being noncorrosive to copper in the copper strip corrosion test, such as to produce no blackening of the copper strip at 122 F. for six hours, said cutting oil having a color on the Lovibond scale (½ inch cell) below 85 and a cutting effectiveness at least approaching that of a dark colored opaque more highly sulfurized heavy duty cutting oil.

Modified Copolymers and Preparation and Uses Thereof, Patent No. 2,786,032 (W. C. Hollyday, Jr. and M. H. Mahan, assignors to Esso Research & Engineering Co.) Hydrocarbon composition comprising a major proportion of a mineral lubricating oil and an oil-soluble pour depressant and viscosity index improver prepared from an oil-insoluble copolymer of styrene being present in amounts of about 50-90% by weight, and about 10-50% of isobutylene, said copolymer having an average Staudinger molecular weight of at least 2000, by alkylating said copolymer with a C_{18} to C_{20} long chain mono-olefin at a reaction temperature of about —50C. to about +40 C.; said C_{18} to C_{20} long chain mono-olefin being present in amounts sufficient to render the alkylated reaction product soluble in mineral lubricating oils; said reaction product being present in an amount sufficient to substantially depress the pour point and improve the viscosity index of the hydrocarbon composition.

Mineral Oil Compositions Containing Tin-Containing Dithiophosphate Compounds, Patent No. 2,786,812 (J. P. McDermott, assignor to Esso Research & Engineering Co.) A mineral oil product having incorporated therein in the range of about 0.01 to 20% by weight of an organo-tetravalent tin compound.

Tin-Containing Thioxanthate Compounds and Lubricants Containing Them, Patent No. 2,786,813 (J. P. McDermott, assignor to Esso Research & Engineering Co.) A hydrocarbon product having incorporated therein in the range of about 0.01 to 20% by weight of an organo-tetravalent tin compound. (Compiled by the ASLE Abstracts Sub-Committees.)

Addition Agent for Oil Compositions and the Like, Patent No. 2,805,203 (C. L. Knapp, Jr. and E. O. Forster, assignors to Esso Research and Engineering Co.) A liquid oily composition of matter comprising a major portion of an essentially hydrocarbon oil and in the range of about 0.01 to 20% by weight, based on the total composition, of an oil-soluble material.

Terpene-P_4S_3-Oxygen Condensation Products and Their Esters and Ester Salts as Lubricating Oil Additives, Patent No. 2,805,217 (G. A. Loughran and E. O. Hook, assignors to American Cyanamid Co.) Triesters obtained by heating five mols of a cyclic terpene hydrocarbon with one mol of phosphorus sesquisulfide and two mols of oxygen at about 110-150 C. and esterifying the product with three mols of a member of the group consisting of monohydric alkanols of from 4 to 18 carbon atoms and nonylphenol.

Textile Conditioning Agent, Patent No. 2,805,992 (F. Fortress, C. Hohing and C. E. Kip, assignors to Celanese Corp. of America) A textile conditioning composition consisting essentially of 35 to 55% of mineral oil; 5 to 45% of bodied sperm oil having a viscosity of about 200 to 400 seconds; 5 to 30% of a partial higher alkyl phosphate containing 1 to 2 alkyl radicals per phosphorus atom and an average of about 10 to 13 carbon atoms per alkyl radical; 5 to 20% of dibutyl ethanolamine; and 10 to 25% of a nonionic surface active agent comprising a mixture of an alkylene oxide derivative of a higher fatty acid having 12 to 18 carbon atoms and an alkylene oxide derivative of a higher fatty alcohol having 12 to 18 carbon atoms, the pH of said composition, when measured as a 2% dispersion thereof in water, being about 7.9 to 8.5.

Textile Lubricant and Process, Patent No. 2,805,993 (W. S. Barnard and A. L. Scarbrough, assignors to National Lead Co.) The process of lubricating a textile fiber during the forming thereof into a yarn, which includes the step of bringing the fiber into contact with an emulsion having a continuous phase of water and a dispersed phase of an oil-organophilic bentonite mixture containing from 0.5% to 25% by weight of an organophilic bentonite.

Lubricant Grease Composition Containing Surface Esterfield Organic Siliceous Organophilic Solid Thickener, Patent No. 2,805,994 (H. J. Liehe and W. L. Hayne, Jr., assignors to Standard Oil Co.) A lubricant grease comprising a major proportion of a mineral lubricating oil, from about 5% to about 20%, by weight, of an organophilic solid thickener consisting essentially of substrate particles of inorganic siliceous materials in a supercolloidal state of subdivision having chemically bound thereto—OR groups, wherein R is a hydrocarbon radical having 2 to 18 carbon atoms in which the carbon atom attached to the oxygen is also attached to at least one hydrogen atom, the substrate particles having a specific surface area of from about 25 to 900 $m.^2/g.$ and having a sufficient number of chemically bound —OR groups per unit of substrate surface area to cause them to be preferentially wetted by butanol in a butanol-water mixture, from about 0.2% to about 5% by weight, of a rust preventive compound selected from the group consisting of an alkenyl succinic anhydride, an alkenyl succinic acid, an alkyl succinic anhydride and an alkyl succinic acid wherein the alkenyl and alkyl radicals contain from about 8 to about 12 carbon atoms, from about 0.05% to about 1% by weight of pentaerythritol mono-oleate and from 0.5% to 1% by weight of a dialkyl phosphate in which the alkyl group contains from about 6 to about 18 carbon atoms.

Lubricating Composition, Patent No. 2,805,995 (D. E. Adelson, assigner to Shell Development Co.) A lubricant comprising a major amount of a lubricating oil and from about 0.01% to about 5% by weight of a reaction product obtained by the methods selected from (a) by first reacting an organic compound selected from the group consisting of oxygen containing organic compounds containing only carbon, oxygen and hydrogen in the molecule and high molecular weight hydrocarbons with hydrogen sulfide-ammonium hydrosulfide at between about room temperature and 100 C. until at least about 4% sulfur has entered the reaction product and thereafter treating about 1 mole of the resulting reaction product with about 1 to 15 moles of a metal halide at a temperature of from about 100 C. to 200 C., said metal being selected from group IV-A of the periodic table and having at atomic number from 50 to 82, inclusive; and (b) a reaction product obtained by first reacting an organic compound as defined in (a) with a metal tetravalent halide, said metal being selected from group IV-A of the periodic table and the halide having an atomic number no greater than 35, in the mole ratio of from 1:15 to 10:1, respectively, and at a temperature of from about 100 C. to about 200 C., and treating said reaction product with hydrogen sulfide-ammonium hydrosulfide between about room temperature and 100 c. until at least about 4% sulfur has entered the reaction product.

Lubricant Composition, Patent No. 2,805,997 (G. J. Benoit, Jr. and A. D. Abbott, assignors to California Research Corp.) A lubricant composition comprising a major portion of an oil of lubricating viscosity and a minor portion, sufficient to inhibit corrosion, of an alkyl monohydric alcohol ester of molybdic acid in which the alkyl group contains from 8 to 24 carbon atoms, said ester being in monomer, dimer and trimer forms.

Lubricant Compositions, Patent No. 2,805,998 (T. L. Cantrell and J. G. Peters, assignors to Gulf Oil Corp.) A lubricating composition comprising a major amount of a lubricating oil and a minor amount, sufficient to improve the detergent characteristics of said lubricating oil, of an aromatic dialkanol amine wherein the aromatic radical is selected from the group consisting of phenyl, tolyl and xylyl, and the alkanol radicals each contain from 2 to 4 carbon atoms, said minor amount being from about 0.5 to about 10 percent by weight of the total composition.

Process for Recovering Rolling Oil, Patent No. 2,806,868 (L. Kovacs). A process for treating the cooling and lubricating liquid containing a fatty rolling oil emulsion water used in the process of continuous cold rolling of steel strip, comprising, the steps of collecting from the main body of the liquid sedimentary and supernatant sludge containing the oil emulsified with water and contaminated with impurities, adding to the oil from about 8 to 27 percent by weight thereof of mineral acid selected from the group consisting of HCl and H_2SO_4, before substantial chemical deterioration of the oil has occurred, at least about 1 to 2 percent acid based on the gross weight of said sludge being added within about 48 hours after the use of the oil in cold rolling as aforesaid, maintaining the mixture after the addition of all of the acid, at an elevated temperature until the emulsion is broken and a water-and-oil insoluble precipitate is formed, and separating the oil from the mixture ready for reuse in the rolling process.

Process for Treating Rolling Oil, Patent No. 2,807,531 (L. Kovacs). A method of preventing deterioration of rolling oil contained in the effluent cooling liquid in the process of cold rolling of steel strip and of producing iron powder from said oil, the said oil being emulsified with water and settled out from the main body of cooling water in the form of supernatant and sedimentary sludge which is contaminated with impurities including free metallic iron and iron compounds, which process comprises separating the fresh wet sludge from the cooling water, extracting the oil from the sludge with a fat solvent, and separating dry oil and dry iron powder from the water and the solvent and from each other.

Lubricant for Bowden Wire Mechanisms, Patent No. 2,807,583 (O. J. Bratz and V. C. J. Peterson, assignors to American Chain & Cable Co.) A lubricant for Bowden wire controls comprising a major amount of petroleum oil and lithium soap forming a grease and finely divided aluminum phosphate, said aluminum phosphate comprising from 1% to 15% of the lubricant by weight.

Corrosion Inhibited Lubricant Composition, Patent No. 2,808,376 (W. Lowe, assignor to California Research Corp.) A lubricating composition comprising a major portion of an oil lubricating viscosity corrosive to metal surfaces in normal use and a minor portion, sufficient to inhibit corrosion of p-xylyenediamine.

Lubricant Composition, Patent No. 2,809,160 (W. T. Stewart and W. Lowe, assignors to California Research Corp.) A lubricant composition comprising a major portion of an oil of lubricating viscosity selected from the group consisting of mineral lubricating oils, alkylene oxide polymers and esters of dicarboxylic acids, said oil being corrosive to metal surfaces in normal use and a minor portion, sufficient to inhibit corrosion, of a phthalic acid of the group consisting of isophthalic acid and terephthalic acid and mixtures thereof.

Lubricant Composition, Patent No. 2,809,161 (W. Lowe and W. T. Stewart, assignors to California Research Corp.) A lubricant composition comprising a major

portion of a mineral lubricating oil in combination with a minor portion of an alkaline earth metal petroleum sulfonate and an alkaline earth metal alkyl phenate, said combination being corrosive to metal surfaces in normal use and a minor portion, sufficient to inhibit corrosion, of a member of the group consisting of m-hexahydrophthalic acid and p-hexahydrophthalic acid and ammonium and N-alkyl ammonium salts thereof having alykl groups of up to 24 carbon atoms each, said minor portion of lubricating oil detergent additive being sufficient to suspend said member in the mineral lubricating oil.

Corrosion Inhibited Lubricant Composition, Patent No. 2,809,162 (W. Lowe, assignor to California Research Corp.) A lubricant composition comprising a major portion of a mineral lubricating oil in combination with an alkaline earth metal petroleum sulfonate and an alkaline earth metal alkyl phenate, said combination being corrosive to metal surfaces in normal use and a minor portion, sufficient to inhibit corrosion of the reaction product of 1 mole of a phthalic acid selected from the group consisting of isophthalic acid and terephthalic acid with from about 0.5 to 5 moles of a glycol titanate selected from the group consisting of triglycol and tetraglycol titanates, said glycols containing from 6 to 10 carbon atoms each.

Lubricant Composition, Patent No. 2,809,163 (E. B. Cyphers and J. H. Bartlett, assignors to Esso Research & Engineering Co.) A lubricating composition comprising a major proportion of a mineral lubricating oil and about 1 wt. % of the condensation product of a sodium dialkyl dithiophosphate, the alkyl groups thereof containing from 10 through 18 straight chain carbon atoms each, and an average of 13.5 carbon atoms, and chlorinated coconut oil containing about 2 chlorine atoms per fatty acid chain.

Oxidation Inhibitors for Lubricating Oil, Patent No. 2,809,164 (G. O. Pruett, assignor to American Cyanamid Co.) An antioxidant composition for mineral oil lubricants comprising from about 1 to about 5 parts of 4,4'-tetramethyl diaminodiphenylmethane and from about 1 to about 40 parts of an antioxidant of the hindred monophenol type.

Detergent Lubricants and Lubricating Oil Additives and Process of Making the Same, Patent No. 2,809,934 (H. E. Alford and J. D. Bartleson, assignors to The Standard Oil Co.) A method of preparing detergent lubricating oil additives and lubricants which comprises reacting the product of the reaction of solvent-extracted lubricating oil stock consisting essentially of hydrocarbon material with an amount of phosphorus pentasulfide in the range of about 0.1 to about 0.75% by weight at a temperature in the range of about 275° to 450 F. with an organic amine base selected from the group consisting of primary and secondary amines having up to 18 carbon atoms in an amount to improve the detergency of the oil within the range from about 0.5 to about 8 moles per atomic weight of phosphorus in the reaction product at a temperature of at least 450° F. for at least one-half hour.

Extreme Pressure Lubricant, Patent No. 2,809,935 (P. R. Chapman, A. A. Manteuffel, and George Wolfram, assignors to The Pure Oil Co.) An extreme pressure lubricant which comprises a mineral oil, an amount sufficient to impart extreme pressure properties to the oil of extreme pressure additive comprising a phosphorized and sulfurized ester of a fatty acid and aliphatic alcohol, and a nitrogen-containing compound comprising at least one member of the group consisting of aliphatic amines having at least one carbon chain of at least 16 carbon atoms, aliphatic amides having at least one carbon chain of at least 16 carbon atoms and aliphatic amine salts of fatty acids of carbon chain of at least 16 carbon atoms, wherein the amine radical has at least 16 carbon atoms, in a polymerization-inhibiting amount.

Oleic Acid Esters of Aryloxy Alcohols and Lubricant Compositions Containing the Same, Patent No. 2,809,936 (R. J. Neely and A. G. Rocchini, assignors to Gulf Research & Development Co.) A lubricant composition comprising a mineral lubricating oil and the ester 1-phenoxy-2-propyl oleate, the amount of said ester being sufficient to produce a lubricant composition having a viscosity index superior to the viscosity index of said mineral oil.

Textile Oil, Patent No. 2,810,694 (D. H. McLean and P. J. Way, assignors to Esso Research and Engineering Co.) A textile oil composition of superior emulsion stability comprising a mineral lubricating oil having a viscosity within the range of about 80-500 SSU at 100 F., about 3 to 10 wt. percent of a monoalkylated phenolic material.

Lubricating Grease Compositions Containing Polyethylene, Patent No. 2,810,695 (D. W. Young, A. J. Morway and A. F. Sayko, assignors to Esso Research and Engineering Co.) A lubricating grease composition which comprises a lubricating oil thickened to a grease consistency with a mixture of a linear, toluene-soluble polyethylene having a molecular weight of from about 6,000 to 25,000 Staudinger and a cross-linked, toluene-insoluble polyethylene, said mixture containing from about 10 to 50% of the cross-linked polyethylene.

Lubricant Composition, Patent No. 2,810,696 (W. Lowe and W. T. Stewart, assignors to California Research Corp.) A lubricant composition comprising a major portion of an oil of lubricating viscosity corrosive to metal surfaces in normal use and a minor portion up to 1.0% by weight of the lubricant composition, sufficient to inhibit corrosion, of a member of the group consisting of ammonium isophthalate, ammonium terephthalate, isophthalamide, terephthalamide and N-alkyl ammonium isophthalates, N-alkyl ammonium terephthalates, N-alkyl isophthalamides and N-alkyl terephthalamides in which the alkyl groups contain a total of 8 to 30 carbon atoms.

Polymerization Process for Preparing Lubricant Additives and Products, Patent No. 2,810,744 (A. H. Popkin, assignor to Esso Research and Engineering Co.) A lubricating oil additive material having the desirable characteristic of improving the pour point of waxy mineral lubricating oil into which it has been incorporated consisting essentially of a copolymer of from 75% to 90% of an alpha-beta unsaturated dicarboxylic acid ester of a mixture of alcohols, said alcohols containing from 8 to 18 carbon atoms per molecule, said mixture of alcohols having an average of from 12 to 14 carbon atoms, with from 10% to 25% of vinyl acetate which has been prepared by a process comprising the steps of admixing the monomers in an inert solvent, heating the mixture to a temperature within the range of room temperature to 250 F. in the presence of a peroxide catalyst, and maintaining a sufficient amount of an oxygen-containing gas present during the reaction so as to maintain the reaction temperature near the equilibrium temperature for a period of time sufficient to obtain said copolymer.

Non-Staining Metal Working Lubricant, Patent No. 2,811,489 (Ernst Laug, assignor to Socony Mobil Oil Co., Inc.) An emulsifiable oil composition consisting essentially of a major proportion of a lubricating oil selected from the group consisting of mineral, animal, and vegetable oil, a minor proportion of an emulsifying agent capable of promoting the formation of an oil-in-water emulsion and a small amount of oxalic acid sufficient to impart non-staining qualities toward non-ferrous metals.

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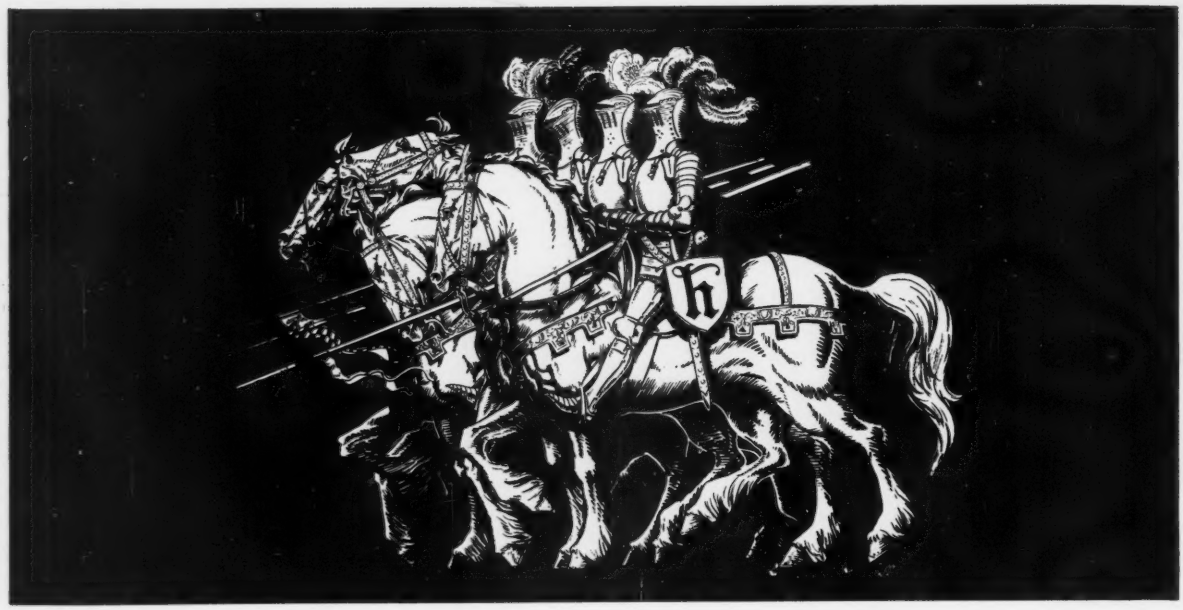

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